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ART. XLI.—*On the Variation in the Strength of a Muscle;* by FRANCIS E. NIPHER, Professor of Physics in Washington University, St. Louis, Mo. With plate VIII.

THE strength of a muscle is the maximum weight which it is capable of lifting at a single impulse. It is practically impossible to measure this strength directly, as it necessitates several trials, during which the muscle becomes fatigued. It may, however, be determined indirectly by a method which I shall make the subject of a future paper.

The evidence which we shall now present of variation in muscular strength from day to day, is seen in the variation in the amount of work done by the muscle, before exhaustion. We present here three series of experiments upon the right arms of myself and a former pupil, Mr. D. A. Myers. The first series consisted in finding the maximum pull, which the muscles could exert upon the spring of a dynamometer. The arm was stretched horizontally, grasping the hook of the dynamometer, the palm of the hand being downward, the pull was exerted upward. The arm moves in the vertical plane which makes an angle of 45° with the transverse plane.*

* Prof. Haughton has criticised this position (Nature, vol. xi, p. 488), his point being that some muscles are called into play irregularly. He suggests that the arm should move in the transverse plane, with the palm of the hand upward. This position is a very unnatural one, and the arm will be wholly fatigued in two or three minutes by simply holding the arm in this position when its weight is supported by an external force. Although Prof. Haughton's opinion on this subject is worthy of grave consideration, yet I am not prepared to adopt it in this case. The manner of experiment is determined to some extent by the end to be accomplished, and I am still of the opinion that I have reduced the errors of experiment to a minimum. This point, however, deserves further attention.

In this case, part of the work of the muscles consists in moving the hook of the dynamometer over a certain space, x, under a constantly increasing strain P. The rest of the work done consists in sustaining the strain P, and the fatigue caused is due wholly to molecular motions in the muscle itself. Prof. Haughton has proposed to call the former work "dynamical," the latter "statical" work.

The dynamical work D is then

$$D=\int P.dx, \text{ or as } P=c\,.\,x$$

(where c is the tension of the dynamometer spring when $x=$ unity.)

$$D=\int cxdx=\frac{cx^2}{2}+c''$$

or between the limits $x=0$ and $x=\frac{P}{c}$

$$D=\frac{P^2}{2c}. \qquad (1)$$

In like manner the statical work S is

$$S=\int Pdt \quad \text{or as} \quad P=c't$$

where c' is the value of P when t is unity—

$$S=\int c'tdt=\frac{c't^2}{2}+c'''.$$

or between the limits $t=0$ and $t=\frac{P}{c'}$

$$S=\frac{P^2}{2c'} \qquad (2)$$

The value of D is measured in kilogram-meters; the value of S is measured in kilogram-seconds. It will be admitted that the statical work of holding a weight of w. kilos upon the out-stretched arm, is equivalent to the dynamical work of lifting w. kilos through a certain space. Calling the total work W, we shall have—

$$W=D+k\,.\,S. \qquad (3)$$

I propose to call k the dynamical equivalent of statical work. No value has yet been obtained for it which can be deemed more than approximate.

In a series of experiments still in my possession, in which the object was to find the relation of the strength (s) to the dynamical work of exhaustion, P was taken provisionally as a measure of the strength. Its variation from day to day is shown graphically on the chart. My experiments are represented by curve F, F; those of Mr. Myers by curve E, E. The strength is laid off on the ordinates. Time is in days laid off on the axis of abscissa. The values of (s) determined on the same day are represented by the small circles which lie in the same vertical.

The second series consisted in finding the dynamical work done before exhaustion, in lifting a weight of 5·0 kgr. through a height of 0·7 meters in 1·25 seconds. The manner of experiment has already been described in former papers.* The results of these experiments are shown on the chart. The broken line A B is the series of constant experiments given in the first table, on page 133 of this Journal, for Feb., 1875. The dates of the individual experiments are not known, but no two experiments were separated from each other by an interval of more than two days. Soon after this series was finished, the series represented by the line B C was begun, and these experiments are accurately represented in time. The ordinates represent the number (n) of times the weight was lifted before exhaustion, and are laid off on the scale to the left of the chart. D D represents the experiments of Mr. Myers with the same weight, laid off on the scale to the right of the chart.

The third series was made with a view of finding the relation of strength to statical work of exhaustion. The statical work consisted in holding a weight of 5·0 kgr. upon the horizontal arm, the position of the arm being the same as before. The time (t) of exhaustion from day to day (in seconds) is shown in the broken lines G, G and K, K the former being my own experiments, the latter those of Mr. Myers.

During the time of these experiments the muscles were kept in gentle training by daily exercises on the swinging rings and parallel bars. This exercise was taken every day, whether experiments were made or not,† and was found very beneficial in reducing the daily variations in strength. On stopping the experiment for a few days the decrease in the power of the muscle is very apparent, and the influence appears most marked upon the observations of the dynamometer. This is due to a difference in training, and it is one of the most difficult points in the whole subject. Two different muscles may have equal strength when measured with the dynamometer, and yet

* This Journal, Feb., 1875, pp. 130–137. Nature. vol. xi, p. 276.

† The time of the summer vacation excepted.

one may be capable of doing twice as much dynamical work as the other with a moderately light weight. This makes it necessary that such experiments should be made on trained muscles.

It will be seen that Mr. Myers is considerably stronger than I, and that variations in the amount of work done are greater for him than for me. This means that variations in strength cause greater variations in the work done by him than in my own case. This is entirely in harmony with the equation given at the close of my paper in this Journal, February, 1875.

During the whole of this series of experiments the size of the muscles did not perceptibly change, while in Myers' experiments the number of lifts with a 5 kgr. weight varied, in two successive experiments (Dec. 20 and 23) from 420 to 1,300.

On the 29th of April, 1873, after a month of exceedingly severe mental work, I was present at a terrible accident, occasioned by the burning of a building. For a quarter of an hour I was under severe mental strain and was for a week completely prostrated. The urinary deposits were enormous, and the condition of the nerves may be inferred from a specimen signature executed, May 6th, after having run violently up a short flight of stairs. Out of about 30 signatures made at that time this was the best. My ordinary penmanship is shown in the signature below, executed on recovery. While in this condition a few experiments were made with the dynamometer, and in lifting the 5·00 kgr. weight, they lie between the dates, April 29 and May 8, inclusive, and are limited by the points marked *a–b* on diagrams F, F and B, C. It will be observed that here, also, the observations with the dynamometer are most affected, while the dynamical work is not perceptibly affected.

Two important results follow from this investigation:

1. After the relation of the strength of a muscle to the dynamical work of exhaustion has been determined, the strength at any time will be most accurately determined, by measuring the dynamical work of exhaustion. On days when from any cause the muscles are temporarily weak, the strength as determined by the dynamometer, and the work of exhaustion with very heavy weights, is less. In exhaustion with lighter weights, however, (5· kgr.) the exercise of the first part of the experiment appears to invigorate the muscle, and the influence of temporary weakness, due to errors in diet, or lack of exercise, or the oppressive atmosphere of the room, is eliminated.

2. The coefficient of muscular power per square centimeter of section of the muscle, is a quantity which varies greatly with different muscles, and with the same muscle at different times: or in other words, the work which a muscle can perform, depends not only upon its size, but also upon its quality.

This helps to explain the different results arrived at in the determination of the coefficient of contraction of different muscles. Thus, the following values in kgrs. per sq. cm. have been found by various experimenters.*

1.	Flexors of arm,	8·99	(Henke.)
2.	" " "	8·19	"
3.	" " "	6·67	(Haughton.)
4.	Extensors of foot,	5·90	(Henke.)
5.	" " "	11·60	(Koster.)
6.	Flexors of leg,	7·78	(Haughton.)

Haughton has pointed out other reasons for such differences, but one of the most important reasons is found in the amount of training which the muscle has received. Hence, muscles which are seldom called into action, have not the same contracting power as those which are daily used.

The experiments here described, as well as those before given in this Journal, were performed while I was an assistant in the laboratory of Prof. Gustavus Hinrichs, to whose kindness I am under many obligations. I also take pleasure in acknowledging experimental aid from Prof. W. C. Preston and Mr. D. A. Myers.

St. Louis, June 15th, 1875.

ART. XLII.—*Studies on Magnetic Distribution;* by HENRY A. ROWLAND, of the Johns Hopkins University, Baltimore.†

PART I.—*Linear Distribution.*

CONTENTS.—I. Preliminary Remarks; II. Mathematical theory; III. Experimental methods for linear distribution; IV. Iron rods magnetized by induction; V. Straight electromagnets and permanent steel magnets; VI. Miscellaneous applications.

I.

In a paper of mine published about two years ago, I alluded to some investigations which I had made in 1870 and 1871 on the distribution of magnetism. It is with diffidence that I approach this subject, being aware of the great mathematical difficulties with which it is surrounded. But as the facts are still in advance of what is known on the subject, and as I see that other investigators‡ are following hard upon my footsteps, I thought it would be well to publish them, particularly as it is no fault of mine that they did not appear some years ago.§

* Haughton's "Animal Mechanics." London, 1873, p. 70.

† Communicated by the author. ‡ Particularly M. Jamin.

§ All the experiments referred to in this paper were made in the winter of 1870–71.

The mathematical theory which I give, although not particularly elegant, will at least be found to present the matter in a new and more simple light, and may be considered simply as a development of Faraday's idea of the analogy between a magnet and a voltaic battery immersed in water. I shall throughout speak of the conduction of, and resistance to, lines of magnetic force, and shall otherwise treat them as similar to lines of conducted electricity or heat, it now being well established from the researches of Professor Maxwell and others that this method gives exactly the same results as the other method of considering the action to take place at a distance.

In arranging this paper I have thought best to give the theory of the distribution first, and then afterward to see how the results agree with experiment; in this way we can find out the defects of the theory, and what changes should be made in it to adapt it to experiment.

At present I am acquainted with two formulæ giving the distribution of magnetism on bar magnets: the first was given by Biot, in his *Traité de Physique Expérimentale et Mathématique*, vol. iii, p. 77, and was obtained by him from the analogy of the magnet to a dry electric pile, or to a crystal of tourmaline electrified by heat. He compared his formula with Coulomb's observations, and showed it to represent the distribution with considerable accuracy. Green, in his "Essay," has obtained a formula which gives the same distribution, but he obtains it by a series of mathematical approximations which it is almost impossible to interpret physically. M. Jamin has recently used a formula of the same form, but I have as yet been unable to find how he obtained it. My own formulæ are also quite similar to these, but have the advantage of being obtained in a more simple manner than Green's, and what is of more consequence, all the limitations are made at once, after which the solution is exact; so that although they are only approximate, yet we know just where they should differ from experiment.

II.

If we take an iron bar and magnetize one end of it either by a magnet or helix, we cause lines of magnetic induction* to enter that end of the bar, and after passing down it to a certain distance to pass out into the air and so around to the bar again to complete their circuit. At every part of their circuit they encounter some resistance, and always tend to pass in that direction where it is the least; throughout their whole course they obey a law similar to Ohm's law, and the number of lines passing in any direction between two points is equal to the dif-

* For difference between lines of magnetic force and lines of magnetic induction See Maxwell's "Treatise on Electricity and Magnetism," arts. 400, 592, and 604.

ference of magnetic potential of those points divided by the resistance to the lines.

The complete solution of the problem before us being impossible, let us limit it by two hypotheses. First, let us assume that the permeability of the bar is a constant quantity; and secondly, that the resistance of the lines of induction is composed of two parts, the first being that of the bar, and the second that of escaping from the bar into the medium, and that the latter is the same at every part of the bar. The first of these assumptions is the one usually made in the mathematical theory of magnetic induction; but, as has been shown by the experiments of Müller, and more recently by those of Dr. Stoletow and myself, this is not true, and we shall see this when we come to compare the formula with experiment. The second assumption is more exact than the first for all portions of the bar except the ends.

Let us first take the case of a rod of iron with a short helix placed on any portion of it, through which a current of electricity is sent. The lines of magnetic induction stream down the bar on either side; at every point of the bar two paths are open to them, either to pass further down the rod, or to pass out into the air. We can then apply the ordinary equations for a derived circuit in electricity to this case.

Let μ be the magnetic permeability of the iron,

R be the resistance of unit of length of the rod,

R′ be the resistance of medium along unit of length of rod,

ρ be the resistance at a given point to passing down the rod,

s be the resistance at the end of the rod,

Q′* be the number of lines of induction passing along the rod at a given point,

Q'_ε*† be the number of lines of induction passing from the rod into the medium along a small length of the rod ΔL,

L be the distance from the end of the rod to a given point,

$$r=\sqrt{\frac{R}{R'}},$$

$$A=\frac{\sqrt{RR'}+s}{\sqrt{RR'}-s}.$$

* These are the surface-integrals of magnetic induction (see Maxwell's "Electricity," art. 402); the first across the section of the bar, and the second along a length ΔL of the surface of the bar.

† It is to be noted that $Q'\varepsilon$, when ΔL is constant, is nearly proportional to the so-called surface-density of magnetism at the given point.

To find ρ, the ordinary equation for the resistance of a derived circuit gives

$$\rho+d\rho=\frac{(\rho+\mathrm{R}d\mathrm{L})\dfrac{\mathrm{R}'}{d\mathrm{L}}}{\rho+\mathrm{R}d\mathrm{L}+\dfrac{\mathrm{R}'}{d\mathrm{L}}},$$

whence $$\frac{d\rho}{d\mathrm{L}}=\frac{1}{\mathrm{R}'}(\mathrm{RR}'-\rho^2),$$

and $$\rho=\sqrt{\mathrm{RR}'}\frac{\mathrm{A}\varepsilon^{2r\mathrm{L}}-1}{\mathrm{A}\varepsilon^{2r\mathrm{L}}+1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

To find Q', we have $$d\mathrm{Q}'=\frac{\mathrm{Q}'\rho}{\mathrm{R}'}d\mathrm{L},$$

whence $$*\mathrm{Q}'=\frac{\mathrm{C}}{\mathrm{A}+1}(\mathrm{A}\varepsilon^{r\mathrm{L}}+\varepsilon^{-r\mathrm{L}}), \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and $$\mathrm{Q}'\varepsilon=\frac{\mathrm{Q}'\rho\Delta\mathrm{L}}{\mathrm{R}'}=r\frac{\mathrm{C}\Delta\mathrm{L}}{\mathrm{A}+1}(\mathrm{A}\varepsilon^{r\mathrm{L}}-\varepsilon^{-r\mathrm{L}}). \quad . \quad . \quad . \quad (3)$$

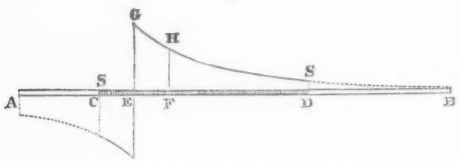
When L is very large, or $s=\sqrt{\mathrm{RR}'}$, we have

$$\mathrm{Q}'=\mathrm{C}_{,}\varepsilon^{r\mathrm{L}_{,}} \text{ and } \mathrm{Q}'_{\varepsilon}=\mathrm{C}_{,}r\Delta\mathrm{L}\varepsilon^{r\mathrm{L}_{,}},$$

in which $\mathrm{L}_{,}$ is reckoned from an origin at any point of the rod.

These equations give the distribution on the part ouside the helix, and we have now to consider the part covered by the helix. Let us limit ourselves to the case where the helix is long and thin, so that the field in its interior is nearly uniform.

1



As we pass along the helix, the change of magnetic potential due to the helix is equal to the product of the intensity of the field multiplied by the distance passed over; so that in passing over an elementary distance *dy* the difference of potential will be $\mathfrak{H}dy$. The number of lines of force which this difference of potential causes in the rod will be equal to $\mathfrak{H}dy$ divided by the sum of the resistances of the rod in both directions from the given point. These lines of force stream down the rod on

* This could have been obtained directly from the equation $\frac{d^2\mathrm{Q}}{d\mathrm{L}^2}=\mathrm{Q}'r^2$, and $\mathrm{Q}'_{\varepsilon}$ from the equation $\mathrm{Q}'_{\varepsilon}=\frac{d\mathrm{Q}'}{d\mathrm{L}}\Delta\mathrm{L}$.

either side of the point, creating everywhere a magnetic potential which can be calculated by equation (2), and which is represented by the curves in fig. 1. In that figure AB is the rod, CD the helix, and E the element of length dy. Now if we take all the elements of the rod in the same way and consider the effect at HF, the total magnetic potential at this point will, by hypothesis No. 1, be equal to the sum of the potentials due to all the elements dy.

Let $\Delta Q'$ be the number of lines of force produced in the bar at the point E due to the elementary difference of potential at that point, $\mathfrak{H}dy$,

$\Delta Q''$ be the number of lines of force arriving at the point F due to the same element,

Q'_ε be the number of lines passing from bar along length ΔL,

ρ_y be the sum of the resistances of the bar in both directions from E,

ρ_x be resistance at F in direction of D,

y be the distance DE,

x be the distance DF,

b be the distance CD,

s'' and s' be the resistance of the bar, &c., respectively at C in the direction of A, and at D in direction of B.

$\mathfrak{H}$ be the magnetizing-force of helix in its interior,

Let

$$A'=\frac{\sqrt{RR'}+s'}{\sqrt{RR'}-s'};\quad A''=\frac{\sqrt{RR'}+s''}{\sqrt{RR'}-s''};\quad r=\sqrt{\frac{R}{R'}};$$

$$\rho_y=\frac{2(A'A''\varepsilon^{2rb}-1)}{(A''\varepsilon^{2ry}+1)\,(A'\varepsilon^{2r(b-y)}+1)}\sqrt{RR'},$$

$$\Delta Q'=\frac{\mathfrak{H}dy}{\rho_y},$$

$$\Delta Q''=\Delta Q'(A''\varepsilon^{rx}+\varepsilon^{-rx})\frac{\varepsilon^{ry}}{A''\varepsilon^{2ry}+1},$$

$$\Delta Q''=\frac{\mathfrak{H}}{2\sqrt{RR'}}\,\frac{A''\varepsilon^{rx}+\varepsilon^{-rx}}{A'A''\varepsilon^{2rb}-1}(A'\varepsilon^{2r(b-y)}+1)\varepsilon^{ry}dy,$$

$$Q''_\varepsilon=\frac{\Delta L}{R'}\int\Delta Q''\rho_x=\frac{\mathfrak{H}\Delta L}{2R'}\,\frac{A''\varepsilon^{rx}-\varepsilon^{-rx}}{A'A''\varepsilon^{2rb}-1}\int_x^b(A'\varepsilon^{2rb}\varepsilon^{-ry}+\varepsilon^{ry})dy,$$

$$Q''_\varepsilon=\frac{\mathfrak{H}\Delta L}{2R'r}\,\frac{A''\varepsilon^{rx}-\varepsilon^{-rx}}{A'A''\varepsilon^{2rb}-1}\,[A'\varepsilon^{2rb}(\varepsilon^{-rx}-\varepsilon^{-rb})+\varepsilon^{rb}-\varepsilon^{rx}]. \quad . \quad . \quad (4)$$

This gives the positive part of Q''_ε. To find the negative part, change x into $b-x$, A' into A'' and A'' into A', and then change the sign of the whole.

When the helix is symmetrically placed on the bar, we have $s'=s''$, $A'=A''$; whence, adding the positive and negative parts together, we have

$$Q''_\varepsilon=\frac{\mathfrak{H}\Delta L}{2\sqrt{RR'}}\,\frac{1-A'}{A'\varepsilon^{rb}-1}\,(\varepsilon^{r(b-z)}-\varepsilon^{rz}), \quad \ldots\ldots \quad (5)$$

which gives the number of lines of induction passing out from the rod along the length ΔL when the helix is symmetrically placed on the rod.

To get the number of lines of induction passing along the rod at a given point, we have

$$Q''=\int_0^x Q''_\varepsilon\,dx=\frac{\mathfrak{H}}{2R}\,\frac{1-A'}{A'\varepsilon^{rb}-1}(\varepsilon^{rb}+1-\varepsilon^{rz}-\varepsilon^{r(b-z)})+C''', \quad (6)$$

where $$C'''=-\frac{\mathfrak{H}}{r}\,\frac{\varepsilon^{rb}-1}{(A'\varepsilon^{rb}-1)(\sqrt{RR'}-s')}.$$

When the bar extends a distance L′ out of both ends of the helix, so that

$$s'=\sqrt{RR'}\,\frac{\varepsilon^{2rL'}+1}{\varepsilon^{2rL'}-1} \text{ and } A'=-\varepsilon^{2rL'},$$

we have $$C'''=-\frac{\mathfrak{H}}{r}\,\frac{(\varepsilon^{rb}-1)(\varepsilon^{2rL'}-1)}{(\varepsilon^{rb}\varepsilon^{2rL'}+1)2\sqrt{RR'}}.$$

It may be well, before proceeding, to define what is meant by magnetic resistance, and the units in which it is measured. If μ is the magnetic permeability of the rod, we can get an idea of the meaning of magnetic resistance in the following manner. Suppose we have a rod infinitely long placed in a magnetic field of intensity $\mathfrak{H}$ parallel to the lines of force. Let Q′ be the number of lines of inductive force passing through the rod or the surface-integral of the magnetic induction across its section; also let a be the area of the rod. Then by definition $\mu=\frac{Q'}{a\mathfrak{H}}$. If L is the length of the rod, the difference of potential at the ends will be $L\mathfrak{H}$; hence

$$Q'=\frac{L\mathfrak{H}}{R_i} \text{ and } R_i=\frac{L\mathfrak{H}}{Q'}=\frac{L}{a\mu},$$

and R in the formulæ becomes

$$R=\frac{R_i}{L}=\frac{1}{a\mu}.$$

It is almost impossible to estimate R′ theoretically, seeing that it will vary with the circumstances. We can get some idea of its nature, however, by considering that the principal part of it is due to the cylindric envelope of medium imme-

diately surrounding the rod. The resistance of such an envelope per unit of length of rod is

$$\frac{1}{2\pi\mu_1} \text{ hyp. log } \frac{D}{d},$$

where D is the diameter of the envelope, d of the rod, and μ_1 the permeability of the medium. We are not, however, able to estimate D. If, however, we have two magnetic systems similar in all their parts, it is evident that beyond a certain point similarly situated in each system we may neglect the resistance of the medium, and $\frac{D}{d}$ will be the same for the two systems. Hence R′ is approximately constant for rods of all diameters in the same medium, and r takes the form

$$r = \frac{2}{d}\sqrt{\frac{1}{\pi\mu R'}}. \quad \ldots\ldots \quad (7)$$

It is evident that the reasoning would apply to rods of any section as well as circular.

In Green's splendid essay (reprint, p. 111, or Maxwell's 'Treatise on Electricity and Magnetism,' art. 439) we find a formula similar to equation (5), but obtained in an entirely different manner, and applying only to rods not extending beyond the helix. In the 'Reprint' β corresponds to my r, and its value, using my notation, is obtained from the equation

$$\cdot 231863 - 2 \text{ hyp. log } p + 2p = \frac{4}{(\mu-1)p^2}, \quad \ldots \quad (8)$$

where $p = \frac{rd}{2}$.

If we make μ a constant in this formula, we must have $p = \frac{rd}{2} = \text{constant}$, hence $r \propto \frac{1}{d}$,

which is the same result for this case as from equation (7).

When μ in the two formulæ is made to vary, the results are not exactly the same; but still they give approximately the same results for the cases we shall consider; and since the formula is at the best only approximate, we shall not spend time in discussing the merits of the two.

III.

Among the various methods of measuring linear magnetic distribution, we find few up to the present time that are satisfactory. Coulomb used the method of counting the number of vibrations made by a magnetic needle when near various points of the magnet. Thus in the curve of distribution most often reproduced from his work, he used a magnetized steel bar 27

French inches long and two lines in diameter placed vertically; opposite to it, and at a distance of eight lines, he hung a magnetic needle 3 lines in diameter and 6 lines long, tempered very hard, and the number of oscillations made by it was determined. The square of this number is proportional to the magnetic field at that point, supposing the magnetism of the needle to be unchanged; and this, corrected for the magnetism of the earth, gives the magnetic field due to the magnet alone. This for points near the magnet and distant from the ends is nearly proportional to the so-called magnetic surface-density opposite the point. At the end Coulomb doubled the quantity thus found, seeing that the bar extended only on one side of the needle.

It will be seen that this method is only approximate, and almost incapable of giving results in absolute measure. The effect on the needle depends not only on that part of the bar opposite the needle, but on portions to either side, and gives, as it were, the average value for some distance; in the next place, the correction at the end, by multiplying by two, seems to be inadequate, and gives too small a result compared with other parts. For at points distant from the end the average surface-density at any point will nearly be equal to the average for a short distance on both sides, while at the end it will be greater than the average of a short distance measured back from the end. To these errors must be added those due to the mutual induction of the two magnets.

The next method we come to is that which has been recently used by M. Jamin, and consists in measuring the attraction of a piece of soft iron applied at different points of the magnet. In this case it does not seem to have been considered that the attraction depends not only on the magnetic density at the given point, but also on that around it, and that a piece of soft iron applied to a magnet changes the distribution immediately at all points, but especially at that where the iron is applied. The change is of course less when the magnet is of very hard steel and the piece of soft iron small. Where, however, we wish to get the distribution of soft iron, it becomes a quite serious difficulty. Another source of error arises from the fact that the coefficient of magnetization of soft iron is a function of the magnetization: this source of error is greatest where the contact-piece is long and thin, and is a minimum when it is short and thick and not in contact with the magnet. Hence this method will give the best results when the contact-piece is small and in the shape of a sphere and not in contact with the magnet, and when the method is applied to steel magnets. But after taking all these precautions, the question next arises as to how to obtain the magnetic surface-density from

the experiments. Theory indicates, and M. Jamin has assumed, that the attractive force is nearly proportional to the square of the surface-density. But experiment does not seem to confirm this, except where there is some distance between the two bodies, at least in the case of a sphere and a plane surface, as in Tyndall's experiments (Phil. Mag., April, 1851). It is not necessary at present to consider the cause of this *apparent* discrepancy between theory and experiment; suffice it to say that the explanation of the phenomenon is without doubt to be sought for in the variable character of the magnetizing function of iron. All I wish to show is that the attraction of iron to a magnet, especially when the two are in contact, is a very complicated phenomenon, whose laws in general are unknown, and hence is entirely unsuitable for experiments on magnetic distribution.

A third method is that used in determining the correction for the distribution on the magnets in finding the intensity of the earth's magnetism. Usually the distribution is not explicitly found in this case; but it is easy to see how it might be. Thus one way would be as follows: Take the origin of coördinates at the center of the magnet. Develop the distribution in an ascending series of powers of x with unknown constant coefficients. Calculate the magnetic force due to this distribution for any points along the axis, or else on a line perpendicular to the magnet at its center. Determine the force at a series of points extending through as great a range and as near the magnet as possible. These experiments gave a series of equations from which the coefficients in the expansion can be determined. Other and better methods of expansion might be found except for short magnets, where the method suggested is very good.

The similarity of this method to that used by Gauss in determining the distribution on the earth is apparent.

A fourth method is similar to the above, except that the direction of the lines of force around the magnet are measured and calculated instead of the force.

The last two methods are very exact, but are also very laborious, and therefore only adapted to special investigations. Thus, by the change in direction of the lines of force around the magnet, we have a delicate means of showing the change in distribution, as, for instance, when the current around an electro-magnet varies.

The fifth method is that used lately in some experiments of Mr. Sears (this Journal, July, 1874), but only adapted to temporary magnetization. At a given point on the bar a small coil of wire is placed, and the current induced in it measured by the swing of the galvanometer-needle when the bar is

demagnetized. It does not seem to have been noticed that what we ordinarily consider as the magnetic distribution is not directly measured in this way; and indeed, to get correct results, the magnetization should have been reversed, seeing that a *large portion* of the magnetization will not disappear on taking away the magnetizing-force where the bar is long. The quantity which is directly measured is the surface-integral of the temporary magnetic induction *across the section* of the bar, while the magnetic surface-density is proportional to the surface-integral of magnetic induction *along a given portion of the bar*. In other words, the quantity measured is Q instead of $\frac{Q_\varepsilon}{\Delta L}$. We can, however, derive one from the other very easily.

The sixth and last method is that which I used first in 1870, and by which most of my experiments have been performed. This consists in sliding a small coil of wire, *which just fits the bar and is also very narrow*, along the bar inch by inch, and noting the induced current over each inch by the deflection of a galvanometer-needle. This measures Q_ε, except for some corrections which I now wish to note. In the first case, to give exact results, the lines of force should pass out perpendicular to the bar, or the coil must be very small. But even when the last condition is fulfilled errors will be introduced at certain portions of the bar. The error is vanishingly small in most cases, except near the ends, and even there it is not large except in special cases; for at this part the lines of force pass forward toward the end of the bar, and so the observation next to the end may be too small, while that at the end is too large. The correction can be made by finding where the lines of force through the center of the section of the coil in its two positions meet the bar. The error from this source is not large, and may be avoided to a great extent.

One very great advantage in the method of induced currents is the facility with which the results can be reduced to absolute measure by including an earth-inductor in the circuit as I have before described (Phil. Mag., August, 1873.) There is also no reaction (except a temporary one) between the magnet and current, so that the distribution remains unchanged. Hence it seems to me that this method is the only one capable of giving exact results directly.

The coils of wire which I used consisted of from twenty to one hundred turns of fine wire wound on thin paper tubes which just fitted the bar and extended considerably beyond the coils. The width of the coils was mostly from ·1 to ·25 of an inch wide and from ·1 to ·2 inch thick. A measure being laid by the side of the given bar under experiment, the coil was moved from one division of the rule to the next very quickly.

and the deflection produced on an ordinary astatic galvanometer noted. After experience this could be done with great accuracy. It might be better in some cases to have the coil slide over a limited distance on the tube, though, for the use I intend to put the results to, the other is best.

Up to 35° Q_ε is nearly proportional to the deflection; and when any larger value is put down on the Tables, it is the sum of two or more deflections. I have not the data in most cases to reduce my results to absolute measure, but took pains to insure that certain series of experiments should be comparable among themselves.

Having measured Q_ε at all points of a rod, we may find Q by adding up the values of Q_ε from the end of the rod.

The magnetizing-force to which the bar was subjected was in all cases a helix placed at some part of the bar. The iron bars were of course demagnetized thoroughly before use by placing them in the proper position with reference to the magnetic meridian and striking them.

In the Tables L is the distance in inches from the zero-point, Q_ε is the deflection of the galvanometer when the helix is passed between the points indicated in the first column. Thus in Table II, 34·7 is the deflection on the galvanometer when the helix was moved from the tenth to the eleventh inch from the zero-point, and so we may consider it as the value of Q_ε at $10\frac{1}{2}$ inches; so that the values of Q_ε refer to the half inches, but Q to the even inches.

In all the calculations the constants in the formulæ were taken to represent Q most nearly, and then the corresponding formulæ for Q_ε taken with the same constants.

For ease in calculating by ordinary logarithmic Tables, we may put $\varepsilon^{rL}=10^{\cdot 4343L}$.

[To be continued.]

ART. XLIII.—*The Effect of the Glacial Epoch upon the Distribution of Insects in North America*; by AUG. R. GROTE, A.M.

(Read before the American Association for the Advancement of Science, at Detroit, Aug. 10th.)

FROM the condition of an hypothesis the Glacial period has been elevated into that of a theory by the explanations it has afforded of a certain class of geological phenomena. The present paper endeavors to show that certain zoological facts are consistent with the presence, during past time, of a vast progressive field of ice, which, in its movement from north to south, gradually extended over large portions of the North

American continent. These facts, in the present instance, are furnished by a study of our Lepidoptera, or certain kinds of butterflies and moths now inhabiting the United States and adjacent territories. Before proceeding with the subject, a brief statement of the phenomena assumed to have attended the advent of the Glacial period is necessary.

At the close of the Tertiary, the temperature of the earth's surface underwent a gradual change by a continuous loss of heat. The winters became longer, the summers shorter. The tops of granitic mountains in the east and west of the North American continent, now in summer time bare of snow and harboring a scanty flora and fauna, became, summer and winter, covered with congealed deposits. In time the mountain snows consolidated into glacial ice, which flowed down the ravines into the valleys. Meanwhile the northern regions of the continent, which may have inaugurated the conditions, submitted extendedly to the same phenomena. Glacial ice, first made on elevations, finally formed at, and poured over, lower levels. Glacial streams finally united to form an icy sea, whose frozen waters slowly plowed the surface of the rocks, and, in their movement from north to south, absorbed the local glacial streams in their course, and extended over all physical barriers. The Appalachians and Rocky Mountains are supposed to have had local glaciers. The animals must always have retreated before this frozen deluge. The existing insects of the Pliocene, in submitting to the change of climate which accompanied the advance of the glacier, must have quitted their haunts with reluctance, and undergone a severe struggle for existence, no matter how gradually they had been prepared for the encounter. We may expect that multitudes of specific formsultimately perished, of whose remains no traces have been perserved.

After this brief statement of the outlines of the opening of the Glacial period, we turn to some facts offered by a study of certain of our existing species of butterflies and moths.

The tops of the White Mountains and the ranges of mountain elevations in Colorado offer us particular kinds of insects, living in an isolated manner at the present day, and confined to their respective localities. In order to find insects like them we have to explore the plains of Labrador and the northern portion of the North American continent, in regions offering analogous conditions of climate to those existing on the summits of these mountains. The genera *Oeneis* and *Brenthis* among the Butterflies, and *Anarta* and *Agrotis* among the Moths, are represented by the same or similar species in all of the above mentioned localities. In the case of the White Mountain butterfly, *Oeneis semidea*, we have a form sustaining itself on a very lim-

ited Alpine area on the top of Mount Washington.* Although there is some doubt whether precisely the same form of *Oeneis* has been discovered in Colorado, the fact remains that *Oeneis*, butterflies exceedingly like it, though registered by us under different specific names, live in Labrador and Colorado. Whether the White Mountain butterfly, *Oeneis semidea*, be, as suspected by Lederer, a modification of some of the Labradorian forms of the genus, or not, the geographical distribution which its genus enjoys cannot be meaningless. The question comes up, with regard to the White Mountain butterfly, as to the manner in which this species of *Oeneis* attained its present restricted geographical area—How did the White Mountain butterfly get up the White Mountains? And it is this question that I am disposed to answer by the action attendant on the decline of the Glacial period.

I have before briefly outlined the phenomena attendant on the advance of the ice-sheet, and I now dwell for a moment on the action which must equally be presumed to have accompanied its retirement. Many of the features of its advance were repeated, in reverse order, on the subsidence of the main ice-sheet or glacial sea. The local glaciers appeared again, separate from the main body of ice, and filled the valleys and mountain ravines, thus running at variance with the main body of the glacier, being determined by local topography A reversal of the temperature shortened the winters and lengthened the summers. Ice-loving insects, such as our White Mountain butterfly, hung on the outskirts of the main ice-sheet, where they found their fitting conditions of temperature and food. The main ice-sheet had pushed them insensibly before it, and during the continuance of the Glacial period, the geographical distribution of the genus *Oeneis* had been changed from a high northern region to one which may well have included portions of the Southern States. And, on its decline, the ice-sheet drew them back again after itself by easy stages; yet not all of them. Some of these butterflies strayed by the way, detained by the physical nature of the country and destined to plant colonies apart from their companions. When the main ice-sheet left the foot of the White Mountains, on its long march back to the pole, where it now seems to rest, some of these wayward, flitting *Oeneis* butterflies were left behind. These had strayed up behind the local glaciers on Mount Washington and so became separate from the main body of their companions,

* See Mr. Scudder's article in the "Geology of New Hampshire," i. 342. Mr. Scudder first pointed out the existence of Alpine and sub-Alpine faunal belts on Mount Washington, and makes the interesting remark. "that if the summit of Mount Washington were somewhat less than two thousand feet higher, it would reach the limit of perpetual snow."

which latter journeyed northward, following the course of the retirement of the main ice-sheet. They had found in elevation their congenial climate, and they have followed this gradually to the top of the mountain, which they have now attained and from which they cannot now retreat. Far off in Labrador the descendants of their ancestral companions fly over wide stretches of country, while they appear to be in prison on the top of a mountain. I conceive that in this way the mountains may generally have secured their alpine animals. The Glacial period cannot strictly be said to have expired. It exists even now for high levels above the sea, while the Esquimaux finds it yet enduring in the far north. Had other conditions been favorable, we might now find Arctic man living on snow-capped mountains within the Temperate zone.

At a height of from 5,600 to 6,200 feet above the level of the sea, and a mean temperature of about 48 degrees during a short summer, the White Mountain butterflies (*Oeneis semidea*) yet enjoy a climate like that of Labrador within the limits of New Hampshire. And in the case of moths an analogous state of things exists. The species *Anarta melanopa* is found on Mount Washington, the Rocky Mountains and Labrador. *Agrotis Islandica* is found in Iceland, Labrador, the White Mountains, and, perhaps in Colorado. As on islands in the air, these insects have been left by the retiring ice-flood during the opening of the Quarternary.

On inferior elevations, as on Mount Katahdin, in Maine, where we now find no *Oeneis* butterflies, these may formerly have existed, succumbing to a climate gradually increasing in warmth from which they had no escape; while the original colonization, in the several instances, must have always greatly depended upon local topography.

I have briefly endeavored to show, that the present distribution of certain insects may have been brought about by the phenomena attendant on the Glacial period. The discussion of matters connected with this theoretical period of the earth's history thus brings out more and more clearly, as it now appears, the fact of its actuality. I hope that my present statements may draw the attention of our zoologists more to the matter, seeing that we have in our own country fields for its full exploration.

Art. XLIV.—*Æstivation and its Terminology;* by Asa Gray.

The term *æstivation*, to denote the arrangement of the parts of the calyx, corolla, &c., in the bud, as well as that of *vernation* for leaves in a leaf-bud, was introduced by Linnæus. He did not elaborate the former subject as he did the latter, and the few terms given to the modes he recognized are for the most part defined merely by a reference to their use in vernation. Æstivation as a botanical character is comparatively recent, and its terminology is not yet quite satisfactorily settled. I propose to consider, 1, what the leading modes are, and 2, how they are to be designated.

1. In the first place, the modes of æstivation may be conveniently divided into two classes, those in which the parts overlap, and those in which they do not.

Of overlapping æstivation, only two principal kinds need be primarily distinguished, viz: 1. where some pieces overlap and others are overlapped, i. e., some have both margins exterior and others both margins interior or covered; 2. where each piece of a circle is overlapped by its neighbor on one side while it overlaps its neighbor on the other. There are mixtures and subordinate modifications of these two, but no third mode.

In æstivation without overlapping, there is first, the rare case in which the parts of the whorl or cycle never come into contact in the bud; and secondly, that in which they impinge by their edges only. There is also the case in which both margins of each piece are rolled or bent inward, and the rarer one in which they are turned outward; and the apex of each piece may comport itself in any of these ways. But these dispositions are those of the pieces or leaves taken separately, and the terms applied to them are the same as in vernation or prefoliation, are used in the same sense, and so are not at all peculiar to æstivation or prefloration. The like may be said of a remaining mode, which belongs, however, to a different category, that in which the parts being united into a tube or cup, this is bodily plaited into folds, or otherwise disposed. In which case the margin of the tube or cup, or such lobes as it may have, may exhibit any of the modes of æstivation above indicated.

Without further notice, then, of this last, the *plicate* or *plaited* æstivation, and of analogous conformations of the tube or cup of a calyx or corolla, or of the disposition of each piece individually (whether *revolute*, *involute*, *reflexed*, *inflexed*, and the like)—about the terminology of which there is no question,—omitting, likewise, for the latter reason, the case of *open* æstivation, there are left three types to deal with:

I. With some pieces of the set wholly exterior in the bud to others.

II. With each piece covered at one margin, and covering by the other.

III. With each piece squarely abutting against its neighbors on either side, without overlapping.

In modes II and III, the pieces are all on the same level and are to be viewed as members of a whorl. In mode I, although they may sometimes be members of a whorl, some parts of which have become external to others in the course of growth, they may, and in many cases must belong either to two or more successive whorls (as in the corolla of *Papaveraceæ*, and even the calyx of *Cruciferæ*, the upper or inner of course covered by the lower or outer), or to the spiral phyllotaxy of alternate leaves.

The type of the latter, and the common disposition when the parts are five, is with two pieces exterior, the third exterior by one edge and interior by the other, and two wholly interior. This is simply a cycle in $\frac{2}{5}$ phyllotaxy, the third piece being necessarily within and covered at one margin by the first, while it is exterior to and with its other margin covers the fifth, this and the fourth being of course wholly interior. So, likewise, when the parts are three, one exterior, one half exterior, and one interior or overlapped, the æstivation accords with $\frac{1}{3}$ phyllotaxy. When of eight or higher numbers the spiral order is usually all the more manifest. When of four or six, the case is one of whorls (opposite leaves representing the simplest whorl), either of a pair of whorls (as in *Epimedium*, *Berberis*, &c.), or a single whorl, the parts of which have overlapped in cyclic order.

2. As to the terminology. Linnæus in the Philosophia Botanica treats only of Vernation, there termed *Foliatio*. For this the former term was substituted, and that of *æstivation* for the disposition of petals in a flower-bud, introduced, as I suppose (not having the volume to consult) in the Termini Botanici, published in the sixth volume of the Amœnitates Academicæ, 1762. I refer to it only through Giseke's edition, 1781. Here the terms are *convoluta*, *imbricata*, *conduplicata*, defined only by reference to the section *vernatio*, and *valvata*, unhappily explained by a reference to the glumes of Grasses, also "*inæquivalvis*; si magnitudine discrepant." *Imbricata* is the only term besides *valvata* which directly relates to the arrangement of petals, &c., *inter se;* and the reference takes us back to something "tectus, ut nudus non appareat," covered as with tiles we may infer. In the Philosophia Botanica, under the section *Foliatio*, the definition of *imbricata* is "quando parallele, superficie recta, sibi invicem incumbunt." This would apply either to mode I, or mode II, according as *invicem* is

understood; but the diagram, tab. x, 6, shows that case I is intended. *Convoluta* refers to the rolling of a petal or leaf by itself, as does *conduplicata* to its folding; but Linnæus gives two figures, one of a single rolled-up leaf, the other of one leaf rolled up within another.

Finally, among the modes of vernation indicated by Linnæus, there is one which it is important here to notice, relating as it does to the arrangement of a pair of leaves in the bud, and evidently quite as applicable to a whorl of a larger number of parts than two, i. e.—

"*Obvoluta*, quum margines alterni comprehendunt oppositi folii marginem rectum." Phil. Bot., 105. Or, in Term. Bot., "pagina superiore lateribus approximatis ita ut alterum latus distinguat alterum folium."

This, as the definition and the diagram in the Philosophia Botanica show, answers in æstivation to mode II. It was early taken up as such by Mirbel (Elem. Phys. Veg. et Bot., 1815, ii, 738, 739), where the polypetalous corolla of *Hermannia* and *Oxalis*, and the gamopetalous corolla of *Apocyneæ* are cited as examples.

Valvate æstivation, our mode III, is rightly defined by Mirbel in the same place, and still earlier by Brown.

Linnæus made no use of æstivation as a character. Nor did Jussieu, except merely that, in his Genera Plantarum, the petals of *Malvaviscus* are said to be *convolute*.

In DeCandolle's Théorié Élémentaire, 1813—a still unsurpassed treatise, upon which, next to the Philosophia Botanica, our botanical glossology rests—neither the word æstivation, nor its synonym, prefloration, is mentioned, and even vernation or prefoliation is equally omitted.

But the history of æstivation as a botanical character began in a work published three years earlier, viz., in R. Brown's Prodromus Floræ Nov. Holl., 1810. The Preface notes that it was first accurately observed by Grew. In it Brown *defines* only the *valvate* mode, "ubi margines foliolorum vel laciniarum integumenti invicem applicati sunt, capsulæ valvularum in modum." In the body of the work, wherever it is important, the æstivation is noted as *valvate*, *imbricate*, *plicate*, *induplicate*, &c.; and the open æstivation (*aperta*) is named by him in a subsequent paper.

Being the first to employ æstivation systematically, and to develop its value, Brown's terminology for its modes may well be considered authoritative. And so indeed it is, as far as it goes. But he did not make one important distinction viz., that between our I and II. Imbricate, in his use, comprises all kinds of overlapping, that of the corolla of *Apocyneæ* and of a Gentian, as well as that of a Primrose. He must have not only noticed the difference, but also appreciated its general

importance, notwithstanding the occasional passage of the one into the other. He must have also observed that in many cases, as in *Asclepias* for instance, the mode II passes into mode III, the valvate, and may possibly have discerned that under a phyllotaxic view these are more nearly related than either is to mode I. I find, however, only one instance in which he has indicated the distinction, viz., in the character of *Burchellia*, furnished to the Botanical Register, t. 435, 1820. Of its corolla it is said: "æstivatione mutuo imbricata contorta." The phrase is interesting, as it seems to recognize the distinction between the mode of overlapping (which is that of our mode II) and the torsion, which only now and then accompanies it. Looking over the Plantæ Javanicæ Rariores to see if there is any later use, I find no instance in which Brown has occasion to speak of this mode II; but it occurs in the portion of his associate, Mr. Bennett, who (on p. 212) describes the petals of *Sonerila* as "æstivatione *convoluta*." Had this term been thus employed by Brown himself, and at an earlier date, I should regard the terminology of these three modes of æstivation as settled, viz.: I. *imbricata*, II. *convoluta*, III. *valvata*. The first and the third are established beyond question, although somewhat remains to be said about the first.

But meanwhile another use has prevailed as respects the second. In DeCandolle's Prodromus, the first general or considerable work after Brown in which terms of æstivation are employed, this mode is almost uniformly characterized as *contorta*. I cannot at this moment trace the term to its origin. It was probably suggested by the name *Contortæ*, said to have been given by Linnæus to the Apocyneous natural order; and it seemed appropriate to the instances in which the strong convolution of rounded petals, as in *Oxalis*, or their lobes, as in *Phlox*, give an appearance like that of twisting, although there is no twist or torsion. But it is to just such cases, in which there is most of seeming twisting on account of the strong convolution, that the term *convolute* is now and then assigned in the Prodromus; as in the character of *Byttneriaceæ*, and that of *Malvaviscus*. The latter may perhaps be explained by the peculiarity that the petals do not uncoil in anthesis. But in *Apocynaceæ*, in the Prodromus, the terms *convoluta* and *contorta* are seemingly employed synonymously, or nearly so (the latter most frequently); at least I see no difference between the æstivation of *Allamanda*, said to be contorted, and that of *Vinca* (*rosea*), said to be convolute. Endlicher in this regard follows the Prodromus. In the new Genera Plantarum by Bentham and Hooker this mode is most commonly designated as *contorta*, sometimes as *contorto-imbricata*, rarely (*Philadelphus*, &c.) *convoluta*. I have myself, from a period as early as 1840, employed the term convolute, thinking it unadvisable to have two names

for the same thing, and wishing to restrict, if it might be, the term contorted to cases of torsion. Adrien de Jussieu, on the other hand, used convolute (with strict Linnæan propriety) for regular imbrication with a high degree of overlapping, thus giving two names to different degrees of the same thing.

It being conceded, I presume, that the mode II should be specifically distinguished, what name, on the whole, ought it to bear? If we follow prevalent usage, *contorta* will be the term. But this term was unknown in this sense to the founders of æstivation, Linnæus and Brown: it correctly expresses the real state of things in only a few cases; and where there is torsion, it leads to a most awkward way of expressing it. We have to write: "lobes of the corolla contorted and twisted: *corollæ lobi contorti et torti*," introducing *dextrorsum* or *sinistrorsum*,* to express the direction of the overlapping and of the torsion, which are not always the same. So that the most current name is the least appropriate. *Convoluta* is as good a name as can be, and its use in the present sense is not unconformable with the Linnæan use in vernation. When well carried out, three or five or more petals, as the case may be, are simply rolled up together. When the overlapping is slight, there is simply the tendency to convolution. But if, as in other nomenclature, priority gives a paramount claim, *obvoluta* will be the proper term, beginning as it did with Linnæus for vernation, and taken up, as it was very early, by Mirbel for æstivation. The only objections to it are, first, that it has never come into systematic use, and second, that *ob* in the composition of botanical terms, commonly stands for obversely or inversely. But *obvoluta* is not burdened with this signification: it is classical for "wrapped round," as is *convoluta* for rolled together. I conclude that one or the other of these two terms ought to be used.

Finally, although there is little, if any, practical misuse, there is some mis-definition, of the term *imbricate* as applied to æstivation. Adrien de Jussieu defines it well (in Cours Élémentaire, 308) in the phrase "La préfloraison spirale est aussi nommé *imbriquée*;" and in noting that when the number stops at five, the pieces fall into two exterior, two interior, and one (the third in the spiral) intermediate, this making what is called *æstivatio quincuncialis*.† This is clear and to the point. But other authors have had a fancy for distinguishing between

* I note with satisfaction that Bentham and Hooker use these terms to signify from left to right, or from right to left, of a person, supposed to stand outside of the closed bud, which is surely the natural position of the observer.

† The name *quincuncial* answers the purpose after definition, and has long been in use; but this arrangement in diagram is wholly unlike the *quincunx*, with its four pieces or stars in the periphery, or at the angles of a square, and one in the center.

quincuncial and imbricate (as if the former were not the typical case of the latter when the parts are five), and so have had to devise something else to answer to imbricate. Alphonse De Candolle (in his Introd. Bot., i, 154, written before phyllotaxy was well understood), after relegating *imbricative* to the category of a crowd of verticils, and remarking that the quincuncial is sometimes confounded with the imbricate, adds: some confound also under this latter name the case in which there is one exterior piece, one interior, and three covered at one margin but free at the other. I know not where this began; but its latest reproduction is in Le Maout and Decaisne's Traité Général, and in the English translation of it. In the diagram the pieces are numbered directly round the circle from 1 to 5, the fifth coming next the first: "so they thus complete one turn of a spiral,"—which shows that Le Maout had vague ideas of phyllotaxy, of which he seems to have invented a new ($\frac{1}{5}$) order. Moreover this is essentially identical with the *cochlear* æstivation of the same work (not of Lindley); and Eichler, in his Blüthendiagramme, adopts this name (unsuitable though it be), for this particuliar arrangement, whatever be the position of the enclosed or enclosing petal. A glance shows that this supposed "true imbricate æstivation" is a slight and not very uncommon deviation (by the displacement of what should be the interior margin of one of the petals during growth) of the mode II, variously termed obvolute, convolute, or contorted æstivation. But it is so intermediate between this and the quincuncially imbricate as perhaps to justify Brown in applying the name imbricate generically to all the overlapping modes. I see, since the above was written, that Eichler, in his Blüthendiagramme, in effect does this. I find also, that Eichler uniformly employs the term *convolute*, or *convolutive*, as I have done, instead of contorted. I should hope, rather than immediately expect, that this use would become general.

ART. XLV.—*Abstract of a Memoir on the "Biological Relations of the Jurassic Ammonites;"* by Professor A. HYATT.*

THE speaker traced the history of the evolution of the order of Ammonoids, showing that the characteristics of the first three stages of the embryo were inherited from a very early period. These were first, the sac-like shell of the embryo containing the equally sac-like beginning of the siphon,—prosiphon as it has since been called by M. Munier-Chalmas; second, the begin-

* From the Proceedings of the Boston Society of Natural History, vol. xvii, December 16, 1874.

ning of the true shell or apex, with its nautilus-like septum, and peculiar nautilus-like umbilicus; third, the depressed and goniatite-like continuation of the form fo the shell with its accompanying goniatitic septa.

These of course represent only their most advanced stage in the Ammonites proper of the Jura and Trias; they are, when first observed in the Silurian and Devonian, exceedingly variable in the length of the periods and other important characteristics even between the varieties of different species. They become invariable in the young as embryonic characteristics only after the lapse of time represented by the Silurian, Devonian, and Carboniferous periods. This variability in the same species in the Silurian shows how recently they were inherited, and their invariability in every individual of the Jurassic show the result of the long ages of inheritance through which the group has passed between that period and the Silurian epoch.

He then showed that in each subordinate group there were certain invariably occurring forms precisely similar to those found in other groups often widely removed in time and very distinct in the structure of the parts. These are apt to occur with a certain fixity of succession which enables the observer to predict with considerable certainty the general characteristics of the succeeding forms of any given group after he has thoroughly studied the development and succession of a few of the lowest. They correspond to what naturalists are in the habit of calling paralled forms, often also representative forms. These forms begin in every group with which I am acquainted with a certain low or open-whorled form and evolve, in course of time and by inheritance, more and more involved whorls, or else the whorls are modified in the characteristics which usually accompany the normal increase of the involution, namely, by the increasing thinness of the shell laterally, flattening of the sides which becomes more and more convergent outwardly, and the tendency of the abdomen to become narrower. This and the origin of most of the groups from certain single ancestral species of the discoidal or open-whorl forms show conclusively that these forms rise independently in each group.

But it must be noticed that they can be only thus limited in each group or series of groups which are genetically connected. The range of forms comprehends every imaginable modification of the original inherited or stock form of the third stage among Ammonites. This is tubular or coniform and has an inherited tendency to grow by increasing the abdominal more than the dorsal side, thus revolving upon itself. Therefore while the choice or selection of the original forms by which a series starts

into being is practically unlimited except by the possibilities of the typical discoidal form of the embryo and young, the subsequent development in each series becomes more and more limited according to the size of the group. The same law of inheritance which renders the embryonic form of the third stage fixed or invariable in each individual of the true Ammonites of the Jura, subsequently accomplishes the same purpose, to a less degree and with greater fluctuation, for the later developed forms and characteristics of each separate series or group, obliging them to evolve, if they progress at all, a certain succession of forms which have been described above.

It will be noticed that I use the word progress in a special sense as applicable to a certain class of paralled forms and not to those with which we shall presently deal, the old-age forms, which though equally perfect in the phenomena of parallelism, cannot be attributable to growth. The former are the mechanical results of the growth or increase in size of the shell of the common embryonic form of the third and succeeding stages of the young, while the latter result from the natural but inevitable loss of growth-force in the adult shell and its parts.

This growth seems to me to be due to the favorable nature of the physical surroundings, primarily producing characteristic changes which become perpetuated and increased by inheritance within the group. We can recognize this in the constantly increasing size of the shell, complication and development of the new parts, as has been shown by Prof. Cope in his "Method of Creation of Organic Types." Though he does not attribute so much to the influence of the physical surroundings as has been done here, the result of my investigations are, as they have been heretofore, very similar to his.

The law or general expression for the mode of inheritance by which this is accomplished is the same for all characteristics, whether of form or structure; namely, that of acceleration. By this I mean the constant tendency of every individual to inherit the characteristics of its parents at earlier periods than those in which they have appeared in the parents themselves. I know of no exception to this law, whether the characteristics are due to a healthy adult condition or to old age; whether they precede or succeed the supposed period of reproduction. This I have already treated of fully in previous publications, and need only refer to the old parallel forms, presently to be treated of, in order to make it clear to every zoologist that senile characteristics must be inherited or these series of senile parallel forms could have no existence.

This constant tendency to reproduce the ancestral characteristics at earlier and earlier stages accounts for the reduction of the principal characteristics of the Nautiloids and Goniatites to

an embryonic condition in the young of the Jurassic Ammonites.

It also accounts for the inheritance of the more and more involved form in each of the subordinate series. This becomes apparent when the parallel forms of any series are traced from the primary discoidal or open umbilicated through the intermediate forms to the most completely involved.

We find in all cases the more discoidal or primary with all its characteristics, whatever they may be, repeated at earlier stages in each species, until at last in some of the most involved, all perceptible traces of its existence are lost. Then and only then can the series be said to die a natural death. When this form appears I have never found another. The reason for this is that in all cases the disappearance of the primary or ancestral form and characteristics of the series is due to the encroachments of the inherited old age characteristics. When these, which are essentially degradational, begin to be inherited in a race, the adult characteristics begin to be confined to younger periods of growth and finally disappear altogether; the shell showing certain old age or inherited senile characteristics from the beginning of the fourth stage. Everywhere this mode of inheritance by acceleration occurs, everywhere it seems to govern the succession of the forms. I have not, however, been able yet to trace the precise connection between all the roots of the secondary series. If this could be completely done, which I fear is impossible at present, no doubt some similar relations would be found.

Besides those parallel forms which may be called progressive, there are others in the same groups which may be shown to be due to the inheritance of the old age of these same parallel forms, and, by comparison with similar forms prematurely produced in different species by disease or local influences, they may be attributed to similar causes, namely, the action of unfavorable surroundings. It is no exaggeration to say that in many instances the small, dwarfed forms produced by disease are very similar to the normal and large old age forms of the same series. This resemblance extends sometimes even to the mode of development. Disease thus produces directly an effect similar to the normal action of the laws of inheritance through a greater or less period of time under the influence of physical surroundings.

The word surroundings is now used instead of environment, for the reason that environment covers the whole ground of physical causes which may have either a remote or immediate effect upon the life of the species.

The environment, or the sum of the physical influences, however favorable it may seem to be, is, as is well known to all

phyiologists, perpetually inimical to the prolonged existence of life, and brings about in the individual the retrograde metamorphoses known as old age, and leads to death by disuse, atrophy and decay of the functions and organs.

These changes in the individual are in precise correspondence with those taking place in a group, and, as has been shown, these characteristics are acted upon in their transmission from individual to individual, during the decline of the group, by the same law of inheritance as are the progressive characteristics during its rise. Thus it becomes possible to compare the life of the individual with the life of the group to which it belongs, the period of growth and development to the period of the progressive evolution of new forms, and the period of old age with its retrograde metamorphoses to the period of decline during which retrogressive forms are evolved. This comparison and the facts noted above enable us to attribute the parallel modifications of forms, whether occurring during the progressive or declining period in the existence of a group, to the direct influence of environment.

Besides these characteristic forms and structural parts which are parallel, there are many others in each group not classified under the head of similiarities but under that of differences, in so far as they distinguish the groups from each other. These may be often followed back to varieties of one species, showing that certain varieties have given rise to the groups. These varieties are few as compared with the whole number of varieties traceable in these original ancestral species.

Thus it seems clear, that these varieties must have had certain advantageous peculiarities enabling them to survive the climatic or geological changes, which destroyed the weaker descendants of the same stock, and that these peculiarities rendered them capable of perpetuating their race until they arose into a group or series of genetically connected forms.

Unless the Darwinian law of natural selection, or the survival of the fittest, does apply to the perpetuation of these structural differences which distinguish groups from each other, I am entirely at loss in my attempts to account for them. I here carefully guard against attributing the origin of these differences to the law of natural selection, but limit its action strictly to the modification of the structural differences which tend to appear first in the varieties and then by inheritance in larger and larger groups and at earlier and earlier stages in the life of the individual.

It may also be shown by Cope's law of the origination of differences by growth that the origin of these differences probably lies in some law of growth under the influence of physical surroundings, supply and kind of food, climate, etc. Thus they

may be said to be due to growth modified and directed by the Darwinian law of natural selection, both of these being directly subject to the influence of environment, or the sum of all the physical influences brought to bear upon the organization.

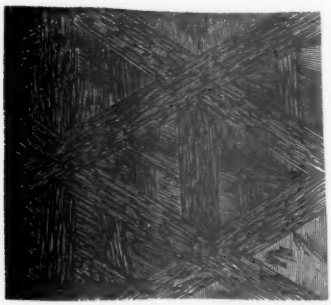
This conclusion, it will be noticed, is strictly in accordance with the general tendency of zoological opinions at the present time and almost identical with the results taught by Herbert Spencer in his works on biology, although I was not aware of this until after they were written. Many of the facts supporting the position assumed have already been published in various scattered papers, but those will be united and accompanied by others since discovered in the partially completed memoir of which this is the abstract.

ART. XLVI.—*A Note in relation to the mass of Meteoric Iron that fell in Dickson County, Tenn., in* 1835; by J. LAWRENCE SMITH, Louisville, Ky.

EVERY metallic particle in the interior of a meteoric stone is a complete miniature type of the large masses of meteoric iron which have been discovered in different parts of the world, but not seen to have fallen, leading to the natural conclusion that they must have fallen at periods anterior to the date of their discovery. And it is an interesting fact in celestial meteorology, that the stony meteorites, with their little particles of metal, fall with comparative frequency. Yet the fall of iron masses free from earthy matter is so rare that we have but four authenticated cases: that of Agram in Croatia, in May, 1751, that of Braunau, Bohemia, in July, 1847, that of Victoria, Africa, in 1862, and the one which now forms the subject of this communication, which fell on the 1st of August, 1835, near Charlotte, Dickson County, Tenn., U. S.; lat. 36° 15′, long. 87° 22′. A short description was given by Professor Troost of Nashville, and published in this Journal in 1845. Prof. Troost dying very shortly after that period, his cabinet of minerals and other objects of natural history were placed in boxes by his executors, and have remained thus until within the past few months, when they passed under my control. The scientific world knowing so little of this meteoric iron, I at once proceeded to its examination; and, as only a small part of one end, weighing two or three hundred grams, had been cut off, it was easy to restore that from a drawing, and obtain a perfect cast of the mass, which has been done. My reason for making the present communication is to call attention to the remarkable features of this most interesting meteorite,

which, although it is forty years since it fell, has not been seen by a half dozen scientific men.

This meteorite fell during the day-time, in a field where several persons were at work, frightening a horse attached to a plough, who ran wildly about the field dragging the plough after him. It struck the ground at the root of a large oak, descending at rather an acute angle, and burying itself in the roots of the tree. The sky was cloudless and a noise was heard preceded by a vivid light. Other particulars connected with its fall, as well as a description of its size and form, have been already published by Prof. Troost. It is of an elongated kidney shape and remarkably symmetrical form, the metal being bright and almost polished on many parts of the surface, and it has remained in this condition ever since it was discovered, although exposed to such atmospheric conditions as usually rust and tarnish iron; it is in this respect unique among meteoric irons, as well as in another particular first noted by Prof. Troost. Although to the naked eye the surface has the appearance of smooth cast iron, the smoothness of the surface in many parts disappears when examined through a lens: "it is then seen to have a reticulated surface, formed by the edges of thin laminæ of metal, separated from each other by an apparently semi-fused or slaggy matter. These laminæ running in an inclined position into the mass, intersect one another at angles of 60°, and forming equilateral triangles, would divide the mass into regular octahedrons. The accompanying cut will better exhibit these lines very much magnified.



Another noteworthy fact in connection with this iron (which is soft and tough) is that when cut and polished, it will resist the tarnishing effects of the ordinary vapors of the laboratory, as I have pieces which have been thus exposed for several months.

By the agency of heat or acid the Widmannstättian figures are developed with exquisite beauty, not equalled except by three or four known meteoric irons. In connection with these figures I will call attention to the delicate parallel lines inside of these figures, which I pointed out several years ago as being peculiar to certain of the irons, they being not contained in all Widmannstättian figures, and which I designate by the term „Laphamite markings."

This iron is not absolutely compact, for one can trace, even with the eye, minute cavities which are distinctly visible with a lens; but I have not yet been able to detect any schreibersite either on the surface or in the interior of the mass.

Its specific gravity is 7·717.

On analysis it was found to consist of

Iron	91·15
Nickel	8·01
Cobalt	·72
Copper	·06

No trace of sulphur was detected, and so minute a trace of phosphorus, that only a few exceedingly small crystals of phosphate of magnesia and ammonia could be discovered in the test made with a gram of the iron, representing only a small fraction of a milligram of phosphorus. In fact, I have never yet analyzed a meteoric iron containing so little phosphorus. In regard to the gaseous contents of this iron, the following were the results obtained by Prof. W. Wright, who made an examination of them at my request.

"The iron being exposed to a red heat gave a little more than twice its volume of gas. It can be estimated as 2·2, without an appreciable error. It did not appear to be given off readily, and doubtless a larger portion would have been obtained if the iron had been in a more thoroughly divided state. An analysis of the gas gave

H	71·04
CO	15·03
CO_2	13·03

There did not appear to be any appreciable quantity of nitrogen."

It is a question of no small interest, in connection with the fall of meteoric irons, whether or not they are heated to a sufficient degree of intensity to fuse the surface of the metal. The present meteorite would appear to solve this question in the negative; for if the surface had been melted the delicate reticulated structure, which is discoverable by the glass, would have disappeared, and it would have had an irregular melted exterior. In the present case this oxide exists on the edges and between the striæ; which serves to show that the surface of the iron, although not melted, was nevertheless intensely heated, and had been preserved from fusion only by the rapid conduction of the heat from the circumference to the center. And this should be the case with nearly all, if not all, the masses of iron which have fallen.

The Braunau iron was not near the point of fusion; otherwise it would have set fire to the rafters of the house in which a

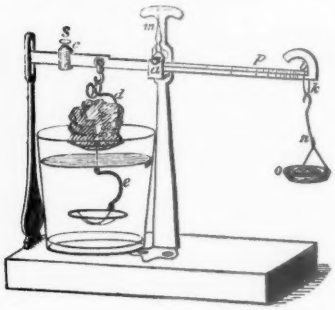
part of it was imbedded at the time of its fall, and the surface of that iron precludes the idea of its having been fused. If this generalization of iron be correct, it has an important bearing upon the hypothesis of the manner in which the Ovifak iron (supposing it to be meteoric) penetrated the basalt in scattered particles just at the time of the outflow of the basalt in a plastic state; for if the iron was not melted in its passage through the air, it could not have penetrated the basalt in such a manner that the particles are completely surrounded by terrestrial basalt. This fact in connection with many others lead me more and more strongly to the conviction, in common with some others, that the Ovifak iron is terrestrial.

On the whole, the iron just described is the most interesting specimen of meteoric iron yet known.

ART. XLVII.—*Specific Gravity Balance;* by ROSWELL PARISH.

THE specific gravity balance described below, is intended for the determination of the specific gravities of minerals, and of other solids heavier than water, without the use of exact weights and without mathematical computation.

The construction of this instrument is shown in the following figure. For use, the fine wire loop *k* with its attachments is removed, and the index *m* is adjusted to the middle line by means of the sliding cylinder with screw *c*.



The mineral (or other solid) is now placed in the wire basket *d*, which is suspended from the knife-edge *s* near *c*, and is counterpoised by the wire pan-holder *n*, one or more shallow metallic pans *o*, and a sufficient quantity of sand (or fine copper punchings), suspended by the wire loop *k* at the notch *b*, as shown in the figure.

The mineral is now transferred to the lower basket *e* (suspended from the upper by fine wire, and immersed in water), and the counterpoise *kno* is moved toward *a* until at some point as *p* it restores the beam to a horizontal position.

The specific gravity is then read off by means of the graduation upon the arm *ab*. This arm is graduated in accordance with the following considerations:

If the exact weight of the counterpoise *kno* be represented by x, then

$$\frac{x.ab}{as} = \text{weight of mineral in air.} \quad (1)$$

$$\text{Also } \frac{x.ap}{as} = \text{weight of mineral in water.} \quad (2)$$

$$(1)-(2) = \frac{x.ab}{as} - \frac{x.ap}{as} = \frac{x.bp}{as} = \text{weight of water displaced.} \quad (3)$$

$$(1)\div(3) = \frac{x.ab}{as} \div \frac{x.bp}{as} = \frac{ab}{bp} = \text{specific gravity of mineral.}$$

Hence the specific gravity is known if the ratio $\frac{ab}{bp}$ is known. This ratio is indicated upon the arm *ab* for as many points as possible.

An arm *ab* 12·6 inches long may be graduated to tenths as high as seven, while low specific gravities may be indicated with much greater exactness.

It will be seen that this balance does not determine weight, and that it renders mathematical computation unnecessary.

Worcester, Mass., Aug. 30, 1875.

ART. XLVIII.—*On Southern New England during the Melting of the Great Glacier;* by JAMES D. DANA. No. III.

III.—REINDEERS IN SOUTHERN NEW ENGLAND.

THE beds in the vicinity of New Haven pertaining to the Champlain or Fluvial period of the Quaternary have recently afforded remains of mammals. I am unable to prove positively that the species belonged to the earlier or "Diluvian" part of the period rather than the later or "Alluvian," and yet I deem this so far probable that I make this paper No. III, in the series on "Southern New England during the melting of the great glacier."

In a memoir on "The Geology of the New Haven region,"* I have described the clay deposits of the Quinnipiac valley between New Haven and North Haven; and on page 176 of this volume I have mentioned facts that appear to prove that they are of glacial origin, and were laid down before the glacial flood had reached its climax. As this clay has afforded the bones recently discovered I here briefly repeat the facts respecting its position and relations.

* Transactions of the Connecticut Academy, vol. ii, 1870, p. 84.

The Quinnipiac valley, south of North Haven village, is to a great extent a region of wet meadows and marshes, nearly five miles long and one broad, deep in peat, and mostly under water at high tide. The clay deposits occur for three and a half miles on both the east and west margins, sometimes extending laterally to the peat region there to stop suddenly, and sometimes graduating into sand-beds before reaching the peat. They are evidently, as I have elsewhere stated, local deposits in what were once still-water areas toward the sides of the wide Quinnipiac basin. The clay-bed seldom reaches more than six feet above high-water level, and is usually covered by four to five or more feet of sand or gravel of the stratified drift. The thickness is over 35 feet at Crafts' clay pit near the Quinnipiac station, two miles south of North Haven, but near the northern limit of the basin, a quarter of a mile south of North Haven, at the Stiles clay pit, only 15 to 18 feet.* The underlying bed, when examined, is of fine sand, called by the workmen "quicksand." The clay is regularly laminated, with the laminæ half an inch to an inch and a half thick; but each lamina really consists of two—one, of the finest "fatty" clay, and the other, lighter in color, of a more or less sandy clay—evidence of alternations of quiet and flowing waters during the progress of the deposition.

Mr. S. P. Crafts, the proprietor of a clay-pit at the village of Quinnipiac†—whose intelligent interest in the geology of the region has kept him on the lookout for fossil leaves and bones, glacial bowlders, and whatever would illustrate the origin of the deposits—has recently brought me from his pit two bones, the second within the month past. One of the bones is a humerus and the other a tibia. The humerus was taken from a depth of 11 feet in the clay bed, and the tibia, subsequently, at a depth of 7 feet. Professor Marsh has given me the following note on these bones for this place:

"The two bones from the clay pit of North Haven are the right humerus and left tibia of a species of Reindeer, about the size of *Rangifer tarandus*. The two bones did not belong to the same individual, the humerus indicating a younger and somewhat larger animal. The tibia is the more characteristic

*Beneath North Haven village the bed thins to 4 or 5 feet and the clay is rather sandy—or what is called "weak clay." In sinking a well about 80 rods east of the North Haven depot, as I was informed by Mr. D. H. Pierpont, 7½ feet of sand were first passed through, next 4 feet of "weak clay," and then 8½ feet of fine quicksand, before reaching tide level. At another place, nearer the river, the bed of clay was 5 feet thick and the sand between it and tide level but 3 feet. At the south end of the Quinnipiac basin, four and a half miles south of North Haven, where the terrace has a height of 42 feet above high-tide level, there are layers of quicksand in the formation; but no clay has yet been found. It may, however, exist there below the sands.

†Four miles from New Haven and two from North Haven.

specimen, and agrees so closely with the corresponding bone of the European Reindeer (*Rangifer tarandus*) that it must have belonged to the same or a very nearly related species. Its resemblance to the tibia of the American Caribou (*Rangifer caribou*) is much less marked. The humerus also evidently belonged to a Reindeer, but the proportions are somewhat similar to those of the Caribou."

Both bones when found were without a trace of wear or fracture. The tibia had lost much of its gelatine and has hence become somewhat cracked from drying since it was exhumed. The humerus has almost the freshness and firmness of a recent bone. Both are of a light brownish color from their long burial. The difference in the conditions of the two bones Mr. Crafts explains by saying that the humerus was imbedded in the laminated clay, and the tibia in a portion of the clay-bed containing sandy seams an inch or so thick, and open therefore to percolating waters. Besides relics of mammals, the clay beds have afforded no organic forms either vegetable or animal. The microscope reveals nothing.

The bones give us an insight into the life of New England in the early part of the Quaternary, proving that Reindeers of the Arctic type were living here. From the facts we gather that:—

1. The bones are probably not of pre-Glacial age. They are certainly not bones which the glacier had taken up from the soil underneath it along with moraine material for transportation and deposition: this being evinced by their freedom from all wear and fracture. The clay was produced through the glacial abrasion of hard stones; and surely if the bones had been in the same mill they would have been ground up too, or at least would have been in some parts worn or broken. It is possible that they were lying in the soil near by when the ice-period began, and that subglacial waters washed them into the basin with the depositing clay; but this is far from probable.

2. They were placed where they were found during the formation of the clay bed, and were deposited at widely different times, four feet in thickness of the clay intervening between them. They therefore belonged to different individuals.

3. The clay bed is of glacial origin. For it contains an occasional bowlder of large size,* and is overlaid by sands and gravel of the stratified drift.

4. If the reindeer bones were not pre-Glacial they must have come from reindeers living in the Quinnipiac valley after the glacier had retreated to the north of the valley. And since the clay-bed is of glacial origin, its bowlders must have come from ice-floes that floated down stream from the retreated glacier.

*This volume, page 177; the bowlder there referred to is of trap.

5. The clay beds of the Quinnipiac valley antedate the great flood due to the final dissolution of the glacier; for at the village of Quinnipiac the bed is overlaid on the west side by beds of coarse gravel, and just south of North Haven the sand and gravel overlying the clay bed has the flow-and-plunge structure so common in the stratified drift.

In my Memoir on the Geology of the New Haven region, I referred the clay-beds to the later or "Alluvian" part of the Champlain or Fluvial period, supposing them to be the mud-deposits made along the borders of the great Quinnipiac basin or inner New Haven harbor, during the more quiet portion of that era of submergence; and the sand-beds overlying and underlying the clay beds at North Haven I referred to the same time. But the discovery since then of the large bowlders in the clay beds,* and of evidence that the deposit of coarse stratified gravel situated along side of the clay pits actually overlies the clay in places, as proved by boring, appears to force us to the conclusion that the clay beds were (1) completed after the glacier had retreated from the valley, and (2) before the final flood.

6. Whether this retreat of the glacier was a *temporary* retreat, produced by a warm interval in the era of ice, or whether it was the *final* retreat, marking the progress of its final dissolution over New England, it is not easy positively to decide. The formation of stratified drift over the New Haven region has no break in the succession of its beds to mark such a retreat and return of the ice; and the clayey stratum contains no layer of vegetable or animal debris as testimony to a warm interval. All that the few facts suggest as to climate is that it was such as reindeers liked, which means that it was cold, and that the ice was still not far off to the north.

Remains of the Reindeer have been found in Northern New York on Racket River, and in Southern, at Sing Sing; in New Jersey, at Vincentown, Burlington County; and in Kentucky at Big Bone Lick. The specimen from Vincentown described by Dr. Leidy† and that from Sing Sing, mentioned by Mr. R. Fisher‡ were antlers. Dr. Leidy says that the Vincentown "antler bears a nearer resemblance to those of the Barren Ground [or Arctic] Reindeer than it does to those of the Woodland Reindeer [or Caribou], but differs in some respects from both." In my Geological Manual I have suggested that these remains may indicate the occurrence on the American Continent of the *second* glacial era so well marked in Europe

* Geology of the New Haven region, p. 84.

† Proc. Acad. Nat. Sci. Philadelphia, 1858, p. 179, and Journ. Acad. Nat. Sci. Philadelphia, vol. vii, 2d series, 1869, on the Extinct Mammalian Fauna, &c., p. 377.

‡ Ibid., 1859, 194.

by the reindeer remains in Southern France. But they may, on the contrary, have belonged to the same time with the Reindeers of the Quinnipiac valley—the era of melting of the great glacier of the *first* glacial era.

The Stiles clay-pit, near North Haven, is reputed to have afforded many years since (as I state on page 86 of my Memoir on the New Haven Region) the antlers of a buck at a depth of 10 or 15 feet. Mr. J. Lorenzo Stiles informed me in 1870 that the antlers were those of the common species of deer. The specimen went to the New Haven City "Museum." The old museum long since disappeared, so that the fact with regard to the species cannot now be ascertained. The antlers may have been those of another Quinnipiac Reindeer.

ART. XLIX.—*Iowa County Meteor and its Meteorites;* by N. R. LEONARD.

ON the evening of February 12th, 1875, at about half past ten o'clock, a very large meteor was seen passing from S.W. toward the N.E., over Northern Missouri and Southern Iowa, and coming to the earth in the form of a shower of stones, in Iowa County, Iowa, a few miles east of Marengo.

At this hour the sky seems to have been quite clear over the greater part of the States named; though light clouds and a sort of haze are spoken of by observers in the counties adjoining the place where the stones fell, so that the meteor was seen throughout a region extending at least 400 miles in length from S.W. to N.E., and 250 miles in breadth.

In their descriptions of the course it pursued the accounts of observers varied with their positions with reference to the place where it fell. Those east of this region thought the course to be toward the west or northwest, those north described it as moving toward the south or the southeast, and in a few cases the statements of different observers in the same town are contradictory as to the direction of its motion.

The brilliancy of its light, and the concussion which accompanied its fall, were such as to attract very general notice, considering the lateness of the hour, and we believe that the observations herewith presented will be found to determine the path it pursued with a fair degree of accuracy.

I will give, first, those descriptions which relate to its general appearance, as nearly as possible in the language of the observers

At Keokuk, Iowa, it is described as "Oblong in figure, with a train ten to twelve times the length of the body, giving an

intensely brilliant light, of crystalline whiteness at the center, fire red on the border, and throwing out red sparks and purplish jets of flame; train less luminous than body, exploded like a rocket. Opinions were divided as to whether any detonation accompanied the explosion." These observations were collected for me by L. C. Ingersoll, M.D., from a number of persons in that city who witnessed the flight.

At Washington, Iowa, Rev. E. B. Taggart in a letter to the Free Press of that city, describes it as of a "Horse-shoe shape, greatly elongated. The outer edge very bright, then a narrow dark space, with a core of intense brilliancy, so vivid as to blind the eyes for a moment. It had not a comet-like train, but a sort of flowing jacket of flame. Detonations heard, so violent as to shake the earth, and to jar the windows like the shock of an earthquake."

At Iowa Agricultural College, Prof. Macomber writes: "In form it was like an immense rocket with streamers flowing from the hinder part, the front being smooth and curved like a sabre. Its color was at first brilliant white, illuminating the sky like a flash of lightning; then fading gradually into yellow, then a deep rich orange, almost scarlet when it burst."

At Sigourney, almost directly under the path of the meteor, Mr. J. A. Donnell, writing to the "Sigourney News," speaks of it as "A globe of fire with pale lines of light radiating from it. The light of the globe very vivid. It appeared to be falling toward the earth from about 10° west of the zenith." He says he could see it dropping through a succession of clouds until it came inside the dome above him, where it apparently stood still for a moment and then passed over toward the northeast. The detonation was compared to the discharge of a 40 gun battery which he had heard in the army.

At Amana, about five miles northeast of the middle of the region where the meteor fell, Mr. F. Christen writes that, "Its light was at first dazzling white, then changed to red. Threw distinct shadows of objects on the street. Fragments seemed to separate, not with violence, but simply as if falling apart; the separation was speedily followed by a disappearance of the meteor."

Mr. G. Holm of *Marengo*, gives an account similar to the last, and in addition says that the descending path was *wave-like* and not a uniform curve. Mr. Frank McClintock of *West Union*, says that "at about the middle of its course it appeared to give a slight dart or bound toward the east." Probably the same wave-like motion spoken of by Mr. Holm, when viewed from a station not far removed from the direction in which the meteor was moving.

At Mt. Pleasant, Iowa, Prof. Mansfield writes that some of

the observers thought that the meteor attained its maximum brightness when about due west of that place. Some of the students who were familiar with the color of the flames of different substances with which they had experimented in the Chemical Laboratory called out at the time that the color of the meteor showed iron and copper.

In computing the path pursued by the meteor I have relied almost entirely upon observations which could be verified afterward, by reason of its having passed near to, or behind some recognized point on a building or other object whose altitude and bearing from the station of the observer have since been ascertained by instrumental measurement.

In giving the data I will denote the location of each observer by mentioning the section, township, and range numbers, which, as our lands are laid out on the rectangular method, will be quite definite.

The following is a list of observations upon which I have relied.

1. At Amana (northwest corner of 26–81–9). Mr. F. Christen first saw the meteor when at an altitude of 10 or 11 degrees and at a bearing of S. 19° W. Soon after he saw it passing near the top of a chimney whose bearing and altitude were respectively S. 26° W., and 17½° and finally saw it separate and disappear at an altitude of 29° bearing S. 65° W.

2. At Mt. Pleasant (4–71–6), there is not a perfect agreement as to the altitude of the meteor when due west of that place. Some thought that it passed very near the moon, others thought that it passed above, and one at least gives its altitude as less than that of the moon. One observer spoke of seeing it when at a bearing of about S. 14° W.

3. At Albia, Monroe County (15–72–17), Mr. Pascal T. Lambert saw it when due east at an altitude of 40° to 45°, and pointed out the place of its disappearance which I found to have a bearing N. 41° 30′ E., or almost exactly in the direction of South Amana, in whose vicinity it fell.

4. Mr. E. H. Warrall of the U. S. Corps of Engineers at Keokuk, Iowa (24–65–5), gave its altitude when at a bearing of about N. 60° W., at between 10° and 12°.

Another observer gave the altitude when near the same place at 10° 30′. Both observers saw the meteor disappear behind a church steeple.

5. Rev. E. B. Taggart, of Washington, Iowa (17–75–7), thought that it passed 10° or 15° west of the moon.

6. Prof. J. K. Macomber of the Iowa State Agricultural College (4–83–24), first saw the meteor when at an altitude of 7° or 7° 30′ and bearing S. 55° E. This observation is almost exactly accordant with one taken independently at the same

place by a student who was engaged at the time in taking meteorological observations.

7. Mr. J. A. Donnell, of Sigourney (2–75–12), thought that the meteor passed about 10° west of the zenith of his place; no means of verifying his observation, and no measures taken.

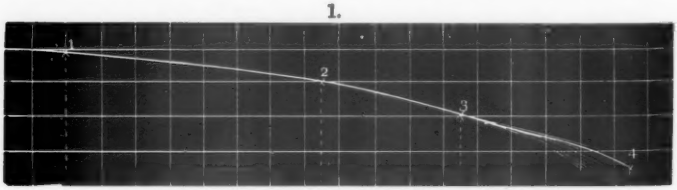
8. Mr. Ream, telegraph operator at Oskaloosa (13–75–17), gave the zenith distance of the meteor when due east as about 35°. No measures taken.

9. C. D. Leggett, Esq., of Fairfield (25–72–10), estimated its zenith distance, when northwest of him, at 25°.

From a comparison of observations 2 and 3, I conclude that the meteor passed over a point a few miles east of the town of Ottumwa. The course can be approximately marked on a map of the state by a line drawn through Agency City and South Amana, the latter being a little west of the center of the district over which the meteorites were found. This would give a bearing of about N. 18° E., and would accord very well with the estimated zenith distances Nos. 8 and 9. It would, however, be at variance with No. 7, and the only explanation I can offer is by saying that it is very difficult for a man to fix, at a glance, the point directly over head, so that we may suspect this observation to be in error. No. 4 corresponds to a point about sixty eight miles from the place where the largest fragment was found, and gives for the altitude fifteen miles. No. 6 indicates a point thirty-eight miles from the same place, and gives for the altitude twelve miles. No. 1 indicates three points in the meteor path, the first nearly accordant with that given by No. 4, and gives about the same result as to height; the second point denoted is at a distance of about twenty-two miles from the end of the path, and at an altitude of eight miles; and the third point is two miles from the end of the path, and at an altitude of two miles.

Figure 1 shows these results to the eye. The sides of the squares are four miles. The points 1, 2, 3, and 4 are sixty-eight, thirty-eight, twenty-two, and two miles from where the largest stone fell. The heights at 1 and 4 of the figure I consider the most reliable; those at 2 and 3 are somewhat uncertain, owing to some uncertainty in the azimuth given by the observations.

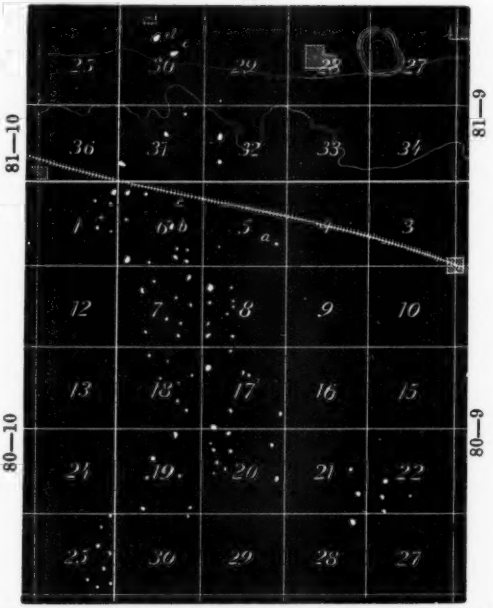
1.



Showing the path of the meteor through the atmosphere.

The product of this meteor-fall was a large number of irregularly shaped stones, varying in weight from a few ounces up to 74 pounds, and aggregating, so far as found, 500 pounds weight, of which I have secured more than 300.

Figure 2 shows the localities where the various fragments were found. The region represented is part of four townships near the northeast corner of Iowa County. The railroad is the Chicago, Rock Island & Pacific Railroad; the village in 36–81–10 is South Amana; that at northeast corner of 10–80–9 is Homestead; that in east line of 27–81–9 is Amana; and that in 28–81–9 is Middle Amana.



Showing the distribution of the stones that have been found.

The dots represent places where fragments have been picked up. We specially note—

a.	in 5–80–9, where the first was found,	weight,	7 lb. 6 oz.
b.	" 6–80–9, broken in striking the ground,	"	43 lb. 8 oz.
c.	" "	"	15 lb.
d.	" 30–81–9, lately found,	"	74 lb.
e.	" " "	"	48 lb.

The largest quantity was probably found in the vicinity of 6–80–9, many pieces in that region weighed 8 to 14 pounds; not many small stones in that locality. Below sections 7 and 8 they were all small. The length of the field is about 7 miles, and its extreme breadth at the southern end about 4 miles.

It is worthy of remark that the regions bordering close upon the river are timbered land, and that especially in sections north of the river and below the two larger stones found, the lands are low and now overflowed, so that larger pieces, hidden by forest or water, may yet be found.

These meteoric stones are many of them entirely covered with the ordinary black coating, and they all present the "pitted" appearance common to such bodies. In several instances there is plain evidence of a fracture having taken place while the stone was as yet some distance from the earth.

These surfaces of fracture are for the most part covered with a secondary coating which sometimes appears to have been partially formed by the pouring over of the melted surface matter from other parts of the surface. In some cases, however, the overflow is only traceable to a short distance from the edge of the fracture, and the remainder is merely discolored as if by smoke.

The want of homogeneity in the structure of the ærolites is shown in several cases, by a sort of beaded circlet surrounding the stone. These circlets are composed of molten drops of iron and seem to lie nearly in a plane, and where this plane has been broken across in the fall, it may be traced over the fresh surface by the presence of unusually large particles of nickeliferous iron. For the following chemical analysis of a fragment of the meteorite I am indebted to Prof. J. Lawrence Smith.

Analysis of Prof. J. Lawrence Smith.—The Iowa County meteorite is of the more common variety, with a dull black coating, and having a rather light gray color in the interior. It has numerous particles of nickeliferous iron disseminated through it, also particles of troilite. The specimen analyzed had a vein running through it which was much richer in iron than the mass to which it belonged.

This meteorite has a hardness rather above the average of its class. I have found it to be composed of

Stony Matter,	81·64
Troilite,	5·82
Nickeliferous iron,	12·54

Of the stony part there was

Soluble in acid,	54·15
Insoluble,	45·85

Separate analyses of these gave for the

	Soluble.	Insoluble.
Silica,	35·61	55·02
Protoxide of iron,	27·20	27·41
Magnesia,	33·45	13·12
Soda with traces of potass. and lithia,	1·45	2·01
Alumina,	·71	·84

This plainly shows that the principal constituent of the soluble portion is an olivine, rich in oxide of iron, approaching hyalosiderite in composition, and that the insoluble part is a pyroxene.

The nickeliferous iron contained, besides traces of phosphorus, sulphur, and copper,

Iron,	89·04
Nickel,	10·34
Cobalt,	·58

From an examination of an entire stone sent me after the completion of the above analysis, I have found the specific gravity to be 3·57. J. LAWRENCE SMITH.

Louisville, Ky., April 15th, 1875.

The first stone from the meteor that was found was discovered lying on the snow, on the afternoon of February 15th, and was adherent to snow and ice underneath. As the weather had been very cold from the time of the meteor-fall to the time of finding this fragment it must have been warm enough when it fell to melt slightly the underlying snow, to which it was afterwards frozen.

I visited the spot shortly afterward and found that it had first struck the ground more than 30 feet to the southwest of the place where it was found, making a slight indentation and bounding thence to the place where it finally came to rest. It was a fragment and showed a secondary coating of rather more than average thickness.

The other meteoric stones were not found until after the melting of the snow in the latter part of March. It is doubtless owing to the frozen condition of the ground and the low angle of descent that only a few of the larger pieces made any indentation in the earth, and we may therefore suppose that a much larger proportion of this meteor-fall has been secured than is usual.

The velocity with which the meteor moved cannot be satisfactorily stated. The maximum velocity, according to the data in my possession, would be about ten miles per second; the minimum about three miles. The most probable value for the last sixty or seventy miles of its course is from six to seven miles per second. This estimate was furnished by Mr. Christie, of Amana, who happened to be walking rapidly at the time the meteor appeared, and continued for a distance of fourteen paces, when having passed the corner of a building that threatened to obstruct his view, he stopped, and watched the meteor until it disappeared, and gave his estimate of the whole time at ten to twelve seconds; and as he saw it through sixty or seventy miles of its path, the resulting velocity would be as above stated.

Iowa State University, Aug. 4th, 1875.

ART. L.—*Brief Contributions to Zoology from the Museum of Yale College.* No. XXXVI.—*On the Post-pliocene fossils of Sankoty Head, Nantucket Island;* by A. E. VERRILL; *with a note on the Geology;* by S. H. SCUDDER.

AN account of the beds at Sankoty Head, with a list of the fossils obtained, was published by Messrs. Desor and Cabot in 1849,* and most of our knowledge of the locality has hitherto been derived from their description.

During the past summer the headquarters of the U. S. Fish Commission were at Wood's Hole, Mass., where an excellent and permanent biological station has been established under its auspices. In connection with the investigation of the marine invertebrates it was considered desirable to examine the fossiliferous deposits to ascertain the facts in regard to the former distribution of the species, and the physical changes that have occurred on our coast. Accordingly one of our dredging parties, consisting of Prof. A. Hyatt, Mr. Sanderson Smith, Mr. C. H. Merriam, and others, visited the locality, while on one of the excursions to Nantucket Shoals, and made a collection of the fossils. Later Mr. S. H. Scudder, of Cambridge, Mass., with the kind coöperation of Mr. W. J. Flagg, made an excavation into the cliff, so as to expose the fossiliferous beds more fully, and Mr. Richard Rathburn visited the locality, and made for the Commission, a large and very valuable collection of the fossils, in which the specimens from the lower and upper beds were kept distinct. Some of our most interesting results have been due wholly to the care with which he made and labelled this collection. From it we learn that the two layers, though only a few inches apart, contain very different assemblages of fossils and were deposited under quite different circumstances; the lower bed contains only such southern species as now inhabit the warm quiet waters of sheltered bays on the southern coasts of New England and farther south; while the upper bed contains many northern species, many of them fragmentary and beach-worn, and all of them, with one unimportant exception, the same species that are now found cast upon the outer beaches of Nantucket and Cape Cod by storms, and living in the colder outer waters, off the same coasts.

In the list published by Desor and Cabot seventeen species were enumerated, and those from the different beds were not kept separate. In our collections there are about sixty species,

* Quarterly Journal of the Geological Society of London, vol. v, p. 340, Feb., 1849. An abstract of the article has been printed by Dr. Packard in the Memoirs of the Boston Soc. of Nat. History, vol. i, p. 252, 1866. See also Proc. Boston Soc. Nat. Hist., vol. iii, p. 79, and this Journal, II, xiv, 50.

nearly all of which can now be assigned to their actual positions in the strata.

Mr. Scudder made a study of the stratification, and as his observations do not agree perfectly with the account given by Desor and Cabot, he has kindly furnished the following description of the locality. The most important point from which it differs from the former one is his conclusion that the fossiliferous beds are conformable to the strata of sandy clay, forming the base of the cliff. Mr. Desor stated that they are unconformable, and referred the clays to the Miocene Tertiary, like those of Martha's Vineyard.

Note on the Post-pliocene Strata of Sankoty Head; by S. H. SCUDDER.

"The sands and gravels forming the bluff at Sankoty Head, Nantucket, rest at base upon a thick bed of light brown sandy clay of uncertain thickness, but extending upward to about twenty feet above the sea-level. As the beds which rest upon it dip to the southwest, and as the anchor brings up clay from Sankoty Head eastward for half a mile, this clay bed is probably of great thickness.

The brown clay is overlaid by four feet of gravel and coarse sand, the coarser parts mostly confined to three or four inches of the uppermost levels; the upper bed is more or less ferruginous and hardens on exposure into a rather compact conglomerate. To this stratum must doubtless be referred a single specimen of a bivalve (probably a Mactra), with valves half open, picked up on the bluff, imbedded in a gravel conglomerate, and like it strongly impregnated with iron. The gravel is followed by about four feet of sands, subdivisible into separate beds, viz: at base, an inch or two of a very fine loose white sand, followed by nearly two feet and a half of a little less fine, closely packed, white sand, with irregular ferruginous streaks through its mass; this is covered by nine inches of a coarse beach sand, with a still coarser sand in pockets; and this again by nine inches of a very fine white sand. Above this comes a foot of ferruginous sand closely packed with masses of tough blue clay, much exceeding the sand in bulk, and forming the floor of the fossiliferous beds.

These consist first, at base, of twenty-two inches of coarse sand in which the oyster, quohog, and common clam are the prevailing forms, the first predominating to such a degree as to make the name of oyster-bed the most appropriate. This merges into a serpula-bed, about twenty-eight inches in thickness, made up almost altogether of large masses of serpula, packed in sand and almost wholly devoid of other fossils. The bed of worn shells superimposed on this is about twenty-two inches in thickness and closely resembles *coquina*, except in the entire want of adhesion between the fragments.

This bed is followed by about ten feet of fine white thinly bedded sand, and this by the stratified drift of the island, to a

depth, as estimated by Desor and Cabot, of forty-two feet; the foot of peat mentioned by them is wanting at this exact locality, (though present a few hundred feet farther south,) leaving the drift covered by five or six feet of dune-sand, more or less intermixed with loam below.

On following the bed of broken shells along the face of the cliff it was found to thin out to about a foot in thickness twenty-five feet on either side of the most prominent point, where the section was made,* and which has doubtless been longer protected than the other parts of the bluff by the former presence of a great mass of clay next the water's edge, called "Antony's Nose"; beyond these twenty-five feet, the bed of broken shells becomes more or less obscured by an admixture of sand, gravel and serpula, and is entirely lost at forty feet distance on either side.

The strata, from the lowermost clay to the bed of worn shells, all dip to the southwest. The uppermost beds incline along the face of the cliff three (3) degrees to the south, while the inclination to the west (along the section dug out of the cliff) is eleven (11) degrees, making a dip of nine (9) degrees to the southwest. All the beds below this also incline eleven (11) degrees to the west, but the inclination of their face toward the south increased gradually in passing downward, until that of the upper edge of the lower clay reaches eleven (11) degrees, making a southwesterly dip of this bed seventeen (17) degrees to the southwest. There is no evidence of any thinning out of the gravel-bed, as stated by Desor and Cabot, nor of any unconformability between this bed and the underlying clays; but, on the contrary, every appearance that the latter belong to the same continuous series as the former.

It is worthy of note that the fossils of this locality lie above the clays, instead of in the clays, as in most of the New England localities of post-pliocene marine shells."

Mr. Rathburn informs me that in the lower shell-bed the shells are extremely abundant and mostly entire, but generally break in pieces when the matrix is removed, and that when first taken out they appear to be soft, but harden on exposure to the air. The matrix is a coarse yellowish ferruginous sand with small pebbles, and the shells have a rusty stain. None of the specimens give any evidence of having been worn by the waves, and many of the most delicate, like *Cumingia tellinoides*, *Angulus tener*, etc., are entire, and sometimes have the valves still united. This is the case, also, with some of the oysters. A large proportion of the quohog-clams (*Venus mercenaria*) are broken into angular fragments with sharp edges and angles. I have ascertained by an examination of large numbers of specimens, both entire and broken, that the breaking is due wholly to lines of fracture developed in the shell by drying or weath-

* I must here express my indebtedness to William J. Flagg, Esq., of New York, who freely gave me the unlimited assistance of his workmen, and enabled me to make a much more thorough exploration than could otherwise have been possible.

ering, just as similar shells often crack into angular fragments in the dry heated air of our museums. Many of the entire specimens of the fossil quohogs, etc., show such fractures extending in different directions across the shell, so that they are ready to break up into several angular fragments under the least strain, or even by a change in the moisture or temperature. This condition of fossil shells is a very frequent one in other localities, and will account for very many cases where the shells are found broken into angular fragments in rocks of other periods. It is evident, both from the condition of the shells in the lower bed and from the peculiar assemblage of southern species, that it was deposited in the very quiet waters of a sandy sheltered bay, entirely protected from the action of the oceanic waves. The assemblage of species is similar to that now living in the protected bays of Southern New England at the depth of 3 to 5 fathoms.* The quohog-clam, oyster, *Modiola hamatus*, *Cumingia tellinoides*, *Arca transversa*, *Urosalpinx cinerea*, and the three species of *Crepidula* are the most abundant and characteristic shells.

The Serpula bed consists mainly of convoluted masses of the tubes of *Serpula dianthus* V., mixed more or less with sand, but without many other fossils. This *Serpula* is still abundant all along the coasts of Southern New England, and southward to the Carolinas, in all sheltered bays and harbors where the water is not brackish, from low-water to 8 fathoms or more. It is often particularly abundant on oyster-beds, and in such localities often completely overgrows the shells, if neglected for a year or two.

The upper shell-bed, according to Mr. Rathburn, consists almost wholly of broken shells, with a little quartzose sand, which is light colored, and not at all ferruginous so that the shells from this bed are not stained rusty yellow by the oxide of iron, like those of the lower one. Many of the fragments are distinctly water-worn and rounded, and most of them have the appearance of those shells thrown on the outer beaches by the surf, or of the dead shells often dredged up in large quantities on sandy bottoms in shallow waters near the shore, or in the vicinity of sand-shoals, where the waves break during storms. The abundance of northern forms, such as *Buccinum undatum*, *Ceronia arctata*, *Astarte castanea*, *Cyclocardia borealis*, *Mya truncata*, *Balanus porcatus*, etc., shows that the bed was

* That the depth could not have been less than 3 fathoms is probable because those species that abundantly inhabit the eel-grass (*Zostera*), which grows in sheltered localities at all depths down to about 2½ fathoms, are either rare or entirely absent, viz. *Bittium nigrum*, *Astyris lunata*, *Triforis nigrocincta*, *Lacuna vincta*, *Littorina rudis*, *Pecten irradians*, etc. That the depth was probably not above 5 or 6 fathoms, I infer because the quohog and oyster, when adult, are seldom found in any abundance below 5 fathoms.

deposited by the cold waters of the outer coast, and their water-worn condition proves that the deposit was made in very shallow water near the shore, or near sand-shoals, swept by the waves. Such deposits may be made at any depth less than about 12 fathoms, but are more commouly made in 2 to 8 fathoms, on our coast.

This locality shows, therefore, that although important changes in the distribution of the land and water, as well as in the level of the land, must have occurred in this region during the time when these strata were being deposited, and subseqently, the temperature of the waters must have been nearly the same then as it is now, and that there must have been, at that time, the same contrast that now exists* between the coldness of the waters on the outer shores and the heat of the sheltered bays and harbors. The fossils of the lower bed indicate, for the water, a summer temperature of 70° to 75° F., while those of the upper bed correspond to a temparature of 55° to 60°, thus showing plainly the influence of the Arctic current along the coast. All the species still inhabit the waters of Southern New England, except *Diodora Noachina* found in the upper bed, but this occurs in Massachusetts Bay, and will probably be found hereafter in the deeper channels among the Nantucket Shoals, where we found this year many northern species that had not

*The nature of the changes that caused the alteration of the temperature and difference of the life indicated by these two beds of fossils will be discussed elsewhere more fully. It may be well, however, to state that my conclusion is that when the lower shell-bed and serpula-bed were forming, a shallow bay existed at this place, from which the outer waters were excluded, either by an island to the eastward of the site of Nantucket, or else by a southward prolongation of Cape Cod. The extensive submerged shoals south of Cape Cod and east and southeast of Nantucket may be the remnants of such lands. Some of these shoals are now covered with stones and rocks (probably drift boulders). Before the deposition of the upper bed some portion of the dry land eastward of the locality must have been submerged by subsidence, or else washed away by the encroachment of the sea (the latter most probably, to judge from the nature of the fossils), thus allowing the cold outer waters to occupy the bay, and the Atlantic surf to fill it with broken shells and beach sand. The protecting land must have been at least 50 feet higher, in its lowest parts, than the present level of the sea. As the shoals east of Nantucket have now several fathoms of water over them a vast amount of denudation must have taken place since that time. This is also shown by the great thickness of the strata of sand and gravel resulting from that denudation, and still remaining above the fossiliferous beds, and doubtless these strata have themselves also suffered great denudation during the period of their emergence from the sea, and subsequently. The partial destruction of islands formerly existing in the region of Nantucket Shoals would also result in partially filling the channels and deeper depressions between them, the final result of surf-action being a levelling one, and this would have been the case both during the period of submergence, and subsequently during that of emergence, but during the period of greatest depression (100 feet or more below the present level) there would have been comparatively little denudation of the deeply submerged islands, but there may have been islands high enough to have been out of water even then, which have since disappeared by denudation. The same reasoning will also apply to St. George's Bank and the great shoals adjacent, all of which are probably islands which have been worn down by the waves below the level of the sea.

previously been found south of Cape Cod. *Modiola hamatus*, which occurs in considerable numbers in the lower bed, is a southern shell, common in the Gulf of Mexico, and on the southern coast as far north as Virginia, but occurring on the southern coast of New England, only locally, in harbors, etc., and generally on beds of oysters that have been transplanted from farther south. For this reason it has been generally supposed that it is not indigenous but has in all cases been introduced with the oysters. However this may be now, it is evident that it was a native species in Post-pliocene times.

The only species that shows any noteworthy variation, when compared with the modern shells from the same region, is the quohog (*Venus mercenaria*). Most of the specimens of this species differ considerably, in the rounder form, thicker shell, and in the greater development of the concentric ridges, from the ordinary quohog-clams seen in our markets. In a lot of large shells of this species obtained from a fisherman at Nantucket, this season, there are many that are equally massive and have the same rounded form, and although the concentric sculpture is not so strongly developed as in many of the fossil shells, there is a decided approach toward them in this respect also. These living Nantucket quohogs certainly resemble the fossil ones more closely than do those from any other locality known to me. But among the fossil specimens (as also among the recent ones from Nantucket) there are some specimens that are as smooth, thin and elongated as the ordinary variety found in our harbors; and intermediate specimens also occur, so there is no reason to suppose that the variation in the fossil shells was anything more than a local variation, such as often occurs in many species at the present time. Nevertheless it may be convenient to designate such special conditions of a species by a particular variety-name. The general absence of such variations in the Post-pliocene shells of the New England coast, as compared with those now living upon it, is certainly very remarkable, considering their great antiquity and the many important changes that have since taken place in the physical conditions of the land and water. Such instances give us the best evidence in regard to the constancy and stability of true specific characters, even when apparently of little or no importance in the economy of the animal itself.

List of Species from the lower Shell-bed.

The names of the species are those used in the Report on the Invertebrata of Southern New England, by the author and Prof. S. I. Smith, in 1st Report of the United States Commissioner of Fish and Fisheries, 1874.

In each case the relative abundance is indicated. I have also added the present distribution on the American coast, in a general way, as well as a few notes on the geological distribution of each species. Fuller information on the distribution of the species has been given in the Report referred to.

MOLLUSCA.

Tritia trivittata Adams. Common.

Florida to Gulf of St. Lawrence; low-water to 40 fathoms. Fossil in the Post-pliocene of Point Shirley, Gardiner's I., Virginia and southward; in the Miocene of Maryland, South Carolina, etc.

Ilyanassa obsoleta Stimpson. Common.

Florida and Gulf of Mexico to Southern Maine; local in the southern part of the Gulf of St. Lawrence; littoral to 2 fathoms. Fossil in the Post-pliocene of Point Shirley, Virginia, South Carolina, etc.

Urosalpinx cinerea Stimpson. Common.

Tampa Bay and Eastern Florida to Massachusetts Bay, and local farther north to Gulf of St. Lawrence; littoral to 10 fathoms. Post-pliocene fossil at Point Shirley, Gardiner's I., Virginia and southward; in the Miocene of Maryland.

Eupleura caudata Adams. One fine specimen.

Gulf of Mexico and Eastern Florida to Cape Cod: low-water to 8 fathoms. In the Post-pliocene from Virginia to Florida; Miocene of Maryland and South Carolina.

Astyris lunata Dall. One specimen.

Alabama and Florida to Massachusetts Bay; low-water to 14 fathoms. Fossil in the Post-pliocene of Gardiner's I. and South Carolina.

Cerithiopsis Greenii Verrill. Four specimens.

South Carolina to Massachusetts Bay; two to 10 fathoms.

Crepidula fornicata Lamarck. Abundant.

Gulf of Mexico to Southern Maine, and local in the southern part of the Gulf of St. Lawrence; low-water to 15 fathoms. Post-pliocene fossil at Gardiner's I., South Carolina, etc.; and Miocene in Maryland and South Carolina.

Crepidula plana Say. Common.

Distribution same as the preceding, from which, however, it is very distinct.

Crepidula convexa Say. Not common.

Distribution like the two preceding, from both of which it is perfectly distinct (although confounded with *C. fornicata* by Tryon and others). Fossil in the Post-pliocene of Virginia and South Carolina.

Odostomia trifida Gould. Common.

New Jersey to Massachusetts Bay; low-water to 5 fathoms.

Odostomia impressa Stimpson. Common.

South Carolina to Vineyard Sound; low-water to 5 fathoms.

Turbonilla interrupta Adams. Several specimens.

South Carolina to Cape Cod; local farther north to the southern part of the Gulf of St. Lawrence, near Prince Edwards' Island; low-water to 15 fathoms. Post-pliocene fossil at Gardiner's I. and in S. Carolina.

Saxicava arctica Deshayes. Rare and small.

Arctic Ocean to Georgia, local and rare south of Long Island; low-water to 50 fathoms. Fossil in the Post-pliocene of Maine and everywhere northward.

Mya arenaria Linné. Abundant.

Arctic Ocean (lat. 78° N.) to South Carolina; low-water to 40 fathoms. Post-pliocene fossil from South Carolina and Virginia to Greenland and Northern Europe.

Corbula contracta Say. One valve.

Florida to Cape Cod.

Ensatella Americana Verrill. Common.

Labrador to Florida; low-water to 25 fathoms. Fossil in the Post-pliocene of Portland, Me., Point Shirley, Gardiner's I., Virginia and South Carolina; Miocene of Maryland, etc.

Angulus tener Adams. Several specimens.

Florida to Gulf of St. Lawrence; low-water to 12 fathoms.

Cumingia tellinoides Conrad. Common.

Florida to Cape Cod; three to 12 fathoms. In the Post-pliocene and Miocene of South Carolina, etc.

Petricola pholadiformis Lamarck. Rare.

Gulf of Mexico to Massachusetts Bay; local in Casco Bay and southern part of the Gulf of St. Lawrence; low-water to 4 fathoms. In the Post-pliocene and Pliocene from Florida to Virginia.

Venus mercenaria Linné. The variety abundant; a nearly typical form not uncommon.

Florida to Massachusetts Bay; local on the southwestern coast of Maine and southern shores of the Gulf of St. Lawrence and Bay of Chaleur; low-water to 8 fathoms. In the Post-pliocene of Point Shirley, Gardiner's I., Virginia, Florida; Miocene from Maryland to South Carolina.

Var. antiqua Verrill. By this name I propose to designate the unusually massive and strongly sculptured variety to which most of the fossil shells belong, and which has been already discussed on a previous page.

The shell is rather obtusely rounded posteriorly, and is thickly covered with prominent concentric lamelliform ridges, which mostly extend entirely across the shell, but are often reflexed, appressed and more or less confluent over the middle region, where the ordinary variety is nearly smooth (except

when young). The violet color can still be traced in some specimens entirely around the inner margin, as in many recent Nantucket examples.

Tottenia gemma Perkins. Few specimens obtained.

South Carolina to Labrador; low-water to 4 fathoms.

Gouldia mactracea Gould. One specimen.

Florida to Cape Cod; 3 to 15 fathoms.

Scapharca transversa Adams. Very abundant and large.

Florida to Cape Cod; low-water to 15 fathoms. In the Post-pliocene of Cape Cod, Gardiner's I., Virginia, South Carolina; Miocene of Virginia and North Carolina.

Mytilus edulis Linné. Common.

Circumpolar; Arctic Ocean to North Carolina; littoral to 50 fathoms. In the Post-pliocene from Florida to Greenland and Northern Europe.

Modiola hamatus Verrill. Common.

Gulf of Mexico to Long Island Sound and Naragansett Bay; littoral.

Crenella glandula Adams. Few specimens obtained.

Labrador to Long Island; 5 to 60 fathoms. In the Post-pliocene of Montreal.

Anomia glabra Verrill.

Florida to Cape Cod; and locally farther north to Nova Scotia; littoral to 20 fathoms. In the Post-pliocene and Pliocene of South Carolina.

Ostrea Virginiana Lister. Abundant and well-grown.

Gulf of Mexico to Cape Cod, and locally farther north, at Damariscotta, Me., and in the southern part of the Gulf of St. Lawrence; low-water to 5 fathoms. In the Post-pliocene of Point Shirley, Gardiner's I., South Carolina, etc. Both the short, rounded specimens and the much elongated and narrow forms occur, as well as all the intermediate states, just as in many modern oyster-beds, showing that in Post-pliocene times the same kind of individual variations prevailed that have perplexed many modern systematists, but they have not yet become specific, nor even definite varietal characters.

Bryozoa.

Hippothoa variabilis V. (*Escharella variabilis* Verrill, in Report on Invert.) Common on *Serpula*, etc.

Florida to Massachusetts Bay; low-water to twenty fathoms.

Biflustra tenuis V. (*Membranipora tenuis* (Desor); Verrill, in Report on Invert.) Common on shells.

Delaware to Massachusetts Bay; low-water to 15 fathoms.

Membranipora catenularia Smitt. Common on shells.

Arctic Ocean to Long Island Sound; low-water to 50 fathoms; northern Europe.

CRUSTACEA; ANNELIDA; PORIFERA.

Panopeus, sp. Several claws were found.

Eupagurus pollicaris Stimpson. A claw, probably from this bed, is recorded by Desor.

Florida to Massachusetts; 2 to 15 fathoms.

Balanus eburneus Gould. Common.

West Indies to Massachusetts Bay; littoral to 3 fathoms.

Balanus crenatus Bruguiére. Common.

West Indies to the Arctic Ocean; 3 to 15 fathoms.

Serpula dianthus Verrill. Very abundant.

North Carolina to Cape Cod; low-water to 15 fathoms.

Cliona sulphurea Verrill. The excavations are abundant in oyster shells.

Florida to Massachusetts Bay; 1 to 15 fathoms.

*List of Species found only in the upper Shell-bed.**

Buccinum undatum Linné. Common.

Arctic Ocean to New Jersey; northern coasts of Europe; low-water to 100 fathoms. In the Post-pliocene, Maine to Labrador and Northern Europe.

Neptunea curta Verrill. Several specimens, one of large size.

Labrador to Massachusetts Bay, and in deep water farther south, to Long Island.

Lunatia heros Adams. Common, but badly broken.

Georgia to Gulf of St. Lawrence; low-water to 40 fathoms. Post-pliocene, Canada, S. Carolina; Pliocene, S. Carolina; Miocene, Maryland to S. Carolina.

Var. triseriata. One specimen occurred.

Neverita duplicata Stimpson. One broken specimen.

Yucatan to Massachusetts Bay; low-water to 10 fathoms. Post-pliocene, Virginia to Florida; Pliocene, S. Carolina; Miocene, Maryland to S. Carolina.

Crucibulum striatum Adams. One large specimen.

New Jersey to Bay of Fundy; low-water to 40 fathoms.

Scalaria Grœnlandica Perry. Recorded by Desor, and doubtless from this bed.

Arctic Ocean to Block Island; 10 to 109 fathoms; Northern Europe. Fossil in Post-pliocene of Northern Europe.

Diodora noachina Gray. Two good specimens.

Arctic Ocean to Cape Cod; 8 to 70 fathoms; northern Europe.

Mya truncata Linné. Several large specimens.

Arctic Ocean to Nantucket Shoals; low-water to 10 fathoms; northern Europe. In the Post-pliocene, Maine to Labrador.

Thracia truncata Mighels and Adams. A few valves, special bed not indicated.

Greenland to Long Island; 10 to 60 fathoms.

* A valve of *Saxicava Norvegica* was found after this list was put in typ Arctic Ocean to Massachusetts Bay.

Clidiophora trilineata Carpenter. One valve.

Florida to Gulf of St. Lawrence; low-water to 30 fathoms.

Macoma fragilis Adams, *var. fusca* (Say). A few valves.

Greenland to Georgia; littoral to 6 fathoms. In Post-pliocene from S. Carolina to Greenland.

Ceronia arctata Adams. Abundant and large.

Gulf of St. Lawrence to Long Island.

Mactra solidissima Chemnitz. Common, fragmentary.

Florida to Labrador; low-water to 12 fathoms. Post-pliocene of Point Shirley, Mass.

Cyclocardia borealis Conrad. Common.

Labrador to New Jersey; 3 to 80 fathoms. In the Post-pliocene of Gardiner's I.; Point Shirley; Labrador.

Cyclocardia Novangliæ Morse. A few valves.

Gulf of St. Lawrence to Long Island Sound; 3 to 40 fathoms.

Astarte undata Gould. One worn valve.

Long Island Sound to Northumberland Straits in Gulf of St. Lawrence; low-water to 100 fathoms. In the Post-pliocene of Gardiner's Island and Point Shirley.

Astarte castanea Say. Abundant.

New Jersey to Nova Scotia; 5 to 40 fathoms. In the Post-pliocene at Point Shirley.

Modiola modiolus Turton. Many worn valves.

Circumpolar; Greenland to New Jersey; low-water to 80 fathoms. In the Post-pliocene of Point Shirley, Canada, and northern Europe.

Anomia aculeata Gmelin. Common.

Arctic Ocean to Long Island Sound; low-water to 100 fathoms.

Bryozoa.

Eschara verrucosa Esper. On shells of Ceronia.

Arctic Ocean to Nantucket Shoals; 3 to 45 fathoms. Northern Europe. In the fossil examples the surface of the cells is covered with radiating ridges, often rising into an eminence in the middle, and is perforated with numerous pores in the grooves. Orifice somewhat semicircular with a median avicularium in front of the proximal edge.

Celleporaria incrassata Smitt (?). Several.

Off Martha's Vineyard to Spitzbergen; 10 to 160 fathoms. The specimens are thick, irregular masses. The apertures are small, rounded, oblong, constricted on the sides by small points projecting inward near the middle, and sometimes with a small proximal spine.

Crustacea and Echinodermata.

Balanus porcatus. Very abundant and large, but broken.

Arctic Ocean to Long Island Sound; 2 to 90 fathoms.

Strongylocentrotus Dröbachiensis A. Agassiz. Spines only. Arctic Ocean to New Jersey; circumpolar; low-water to 430 fathoms. Post-pliocene of Maine and northward.

List of Species found in both Shell-beds.

	Lower Bed.	Upper Bed.
Urosalpinx cinerea	Common.	One.
Tritia trivittata	Few.	Common.
Ilyanassa obsoleta	Few.	Few.
Crepidula fornicata	Abundant.	Few.
Crepidula plana	Common.	Few.
Ensatella Americana	Abundant.	Few.
Mya arenaria	Abundant.	Few.
Saxicava arctica	Few.	Common.
Venus mercenaria	Abundant.	Few.
Scapharca transversa	Abundant.	Few.
Mytilus edulis	Few	Common.
Crenella glandula	Few.	Several, large.
Ostrea Virginiana	Abundant.	Few.

Most of these belong to the fauna of the warm sheltered bays, and their occurrence in the upper bed may have been accidental in many cases. The few worn shells of such species, though found in the upper bed, may have been originally deposited in the lower one and afterward washed out by the waves and redeposited in the upper one.

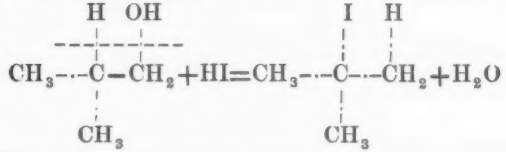
The absence of many species ordinarily abundant in the clay-beds of our New England Post-pliocene, (e. g., the species of *Nucula*, *Yoldia*, *Leda*, etc.), is doubtless due to the fact that such species lived only on muddy bottoms, while both of these deposits were made on sandy bottoms. They are, in fact, characterized by the nearly complete absence of all true muddy-bottom species.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On Trimethyl-carbinol, and its supposed occurrence among the products of Fermentation.*—In examining a crude fusel oil, obtained from a manufactory of potato-spirit, which contained only a small quantity of amyl alcohol, Freund converted the isobutyl alcohol, boiling between 107° and 110°, which was principal product, into isobutyl chloride by heating with fuming hydrochloric acid in sealed tubes. Beside this substance, which boiled between 66·5° and 69°, 120 grams of a chloride boiling at 50°–53° was separated; and this on being heated with water in sealed tubes for ten hours gave trimethyl-carbinol, distilling from 82° to 85°, and solidifying on cooling. It was at first supposed, that as Butlerow has stated, this tertiary alcohol was contained in the crude product, being a product of the fermentation;

but the improbability of the existence of at least 12 per cent of this substance in a most carefully fractionated product such as was used in preparing the chloride, when it had a boiling point lower by 25°, led to the supposition that the trimethyl-carbinol was produced from the isobutyl alcohol itself, by the action of the hydrochloric acid. Pure isobutyl alcohol was taken and heated as above with hydrochloric acid; the tertiary chloride was obtained and converted into the alcohol by the action of water. Further experiments showed that the quantity produced depends on the relative amount of hydrochloric acid; and that hydrobromic and hydriodic acids act similarly. The reaction is as follows:—



The author recommends this reaction for the preparation of trimethyl-carbinol. Isobutyl alcohol is saturated with HCl, five parts fuming acid are added, and the whole is heated in a water-bath for 24 hours.—*J. pr. Ch.*, II, xii, 25, July, 1875. G. F. B.

2. *On the Preparation of Epichlorhydrin.*—PREVOST recommends, instead of treating dichlorhydrin by potassium or sodium hydrate in the cold, as in the usual method for the preparation of epichlorhydrin, to warm the dichlorhydrin in a roomy retort with a receiver attached, to a temperature not exceeding 130°, and to add sodium hydrate gradually; 250 grams being taken for 550 c.c. of dichlorhydrin. At the given temperature the epichlorhydrin distills over with the vapor of water. The process is more rapid and the yield is much larger than in the one formerly employed.—*J. pr. Ch.*, II, xii, 160, July, 1875. G. F. B.

3. *On Three new Pinacolins.*—The name pinacolin was given by Fittig to a body obtained by dehydrating pinacone, and extended by Butlerow to a class of acetones which contained tertiary-alcohol radicals. Pinacolin itself according to Butlerow is methyl-trimethylcarbyl-acetone, $C(CH_3)_3{-}{-}CO{-}{-}CH_3$. WISCHNEGRADSKY, under this chemist's direction, has prepared three new bodies belonging to this class, two of which are isomeric and contain seven atoms of carbon while the third contains eight. If one molecule of trimethyl-acetyl chloride be added carefully to two of zinc-ethyl, a violent reaction takes place and a solid substance is obtained having an odor like camphor and like mint, and a specific gravity of 0·831 at 0°. Analysis showed it to be ethyl-butyl-pinacolin, having the rational formula $C(CH_3)_2{-}.{-}CO{-}.{-}C_2H_5$. The other bodies were obtained by the action of ethyl-dimethyl-acetyl chloride upon zinc-methyl and zinc-ethyl respectively. The first is methyl-amyl-pinacolin, $C(C_2H_5)(CH_2)_3{-}{-}CO{-}{-}CH_3$, isomeric or rather metameric with ethyl-butyl-pinacolin, and having a boiling point 6·5° higher. The second is ethyl-amyl-pinaco-

lin, $C(C_2H_5)(CH_3)_2$- -CO- -C_2H_5, having a specific gravity of 0·845 at 0° and boiling at 150·5° to 157·5°. By the oxidation of these pinacolins, they are split up, the CO group remaining with the tertiary radical. The author is continuing the investigation.—*Liebig's Annalen*, clxxviii, 103, Aug., 1875. G. F. B.

4. *Salylic acid identical with Benzoic.*—In 1860, Kolbe and Lautemann reduced chlorsalylic acid with sodium amalgam and obtained an acid which they called salylic acid, and which, though the formula was identical with that of benzoic acid, the authors believed, on account of the behavior of the acid and its salts, to be only an isomer of this acid. This opinion having been called in question by Reichenbach and Beilstein in 1864, who obtained benzoic acid by distilling salylic acid with water, KOLBE has re-examined the question more thoroughly, using for the reduction a kilogram of chemically pure chlorsalylic acid. A heavy sandy crystalline powder without odor was obtained entirely different in appearance from benzoic acid, as was also its lime salt. But on distillation with water pure benzoic acid went over, leaving in the retort a minute quanity of a pale yellow greasy substance. That this was the cause of the differences observed was proved by again mixing it with the benzoic acid; on crystallization the form of salylic acid returned. It hence appears that only benzoic acid is produced in the reduction of chlorsalylic acid; and that a quantity of some fatty body, produced during this process, so minute as not to affect the analytical results, is capable of altering the entire external appearance of the product. Treatment with permanganate also removes the impurity and yields pure benzoic acid; possibly by oxidizing the reduction product to benzoic acid.—*J. pr. Ch.*, II, xii, 151, July, 1875. G. F. B.

5. *On the Reduction-product of Chlordracylic acid.*—Inasmuch as Kolbe had shown in the above paper that the reduction-product of chlorsalylic (metachlorbenzoic) acid was benzoic acid, it occurred to HARTMANN that the same fact might be true of chlordracylic acid (parachlorbenzoic acid). The acid was prepared by the action of phosphoric chloride upon paraoxybenzoic acid. The product of its reduction was benzoic acid, disguised as before by the presence of some tarry substance.—*J. pr. Ch.*, II, xii, 204, Aug., 1875. G. F. B.

6. *Use of Salicylic acid in Titrition.*—WEISKE proposes to replace the usual litmus solution in titrition by salicylic acid. The acid is dissolved in water, filtered, and to the solution a few drops of ferric chloride is added. To the intensely colored solution, very dilute soda solution is added carefully from a burette to exact neutralization, whereby the liquid becomes reddish-yellow. If now a few cubic centimeters be added to the liquid to be titered, the latter remains uncolored. But as the point of neutralization is reached by the addition of the soda solution, the liquid acquires a deeper and deeper violet tint, which suddenly and immediately disappears again when the soda is added in the slightest excess. The final reaction is sharp and the results are much better than with litmus.—*J. pr. Ch.*, II, xii, 157, July, 1875. G. F. B.

7. *On the Synthesis of Malonic acid.*—PINNER some time ago showed that when zinc and hydrochloric acid acted on trichlorlactic acid there was produced, not monochlorlactic acid, but, by the loss of a molecule of water, chloracrylic acid. He now finds that if ethyl chloracrylate be boiled with barium hydrate, there is formed in considerable quantity a difficultly soluble barium salt, which yields an acid crystallizing from ether in large prisms and identical with malonic acid. It fuses at 132° and yields salts identical with those of malonic acid. The author represents the reaction in three stages: 1st. The replacement of the chlorine by hydroxyl producing acryl-lactic acid:—

$$CHCl{=}{=}CH{-}{-}COOH+HOH=CH(OH){=}{=}CH{-}{-}COOH+HCl$$

2d. The addition of a molecule of water and then by rearrangement forming malonic aldehyde:—

$$CH(OH){=}{=}CH{-}{-}COOH+HOH=CH(OH)_2{-}{-}CH_2{-}.{-}COOH$$

$$CH(OH)_2{-}{-}CH_2{-}.{-}COOH=COH{-}{-}CH_2{-}.{-}COOH+HOH.$$

3d. By oxidation giving $COOH{-}{-}CH_2{-}{-}COOH$, malonic acid. —*Ber. Berl. Chem. Ges.*, viii, 963, July, 1875. G. F. B.

8. *On the Action of Chlorine on Pyrogallol.*—STENHOUSE and GROVES have investigated the action of chlorine on pyrogallol. When an acetic acid solution of this substance is saturated with chlorine in the cold, it becomes of a pale orange-red color. It is then placed in water at 70° for 20 minutes, the chlorine being continued, then rapidly cooled and a third of strong hydrochloric acid added, the chlorine continued for an hour, and the whole allowed to stand for 24 hours. Crystals are obtained which when purified appear as brilliant orthorhombic prisms insoluble in water, soluble freely in ether, and affording on analysis the empirical formula $C_{18}H_7Cl_{11}O_{10}$. To this substance the authors give the name mairogallol. If a solution of pyrogallol in acetic acid be saturated with chlorine in the cold as above, then concentrated hydrochloric acid added and a rapid current of chlorine passed through it, it effervesces strongly and in a few minutes solidifies to an orange-colored mass. After purification, crystalline crusts are obtained consisting of minute colorless radiating needles, easily soluble in water and alcohol and affording on analysis the formula $C_{18}H_6Cl_{12}O_{12}+(H_2O)_2$. This the authors call leucogallol. It is quite unstable.—*Jour. Chem. Soc.*, II, xiii, 704, Aug. 1875. G. F. B.

9. *On the Constitution of Emodin.*—Emodin is a constituent of rhubarb-root discovered by De la Rue and Müller in 1857. LIEBERMANN has succeeded in determining its rational constitution. The material operated on was obtained from Trommsdorff, in the preparation of chrysophanic acid. Heated with zinc dust, emodin yielded a hydrocarbon closely resembling anthracene but having a higher fusing point. Oxidation with chromic acid gave a white product soluble in concentrated sulphuric acid, which after precipitation passed only slowly into alizarin on fusion with potash. Treatment with acetic oxide gave two products: one in

gold-yellow plates, the other in bright yellow needles. These bodies proved to be mono- and tri-acetyl-emodin and led to the formula $C_{15}H_{10}O_5$ for emodin itself. It differs from purpurin in having CH_2 more; or in having a methyl group in place of H. Hence the hydrocarbon which it yields is not anthracene but methyl-anthracene. This was proved by finding that it gave anthraquinone-carbonic acid on oxidation. From these data, Liebermann concludes that emodin is a tri-oxymethylanthraquinone of the following formula:

$$C_{14}H_5\begin{cases}CH_3\\(OH)_3\\COOH.\end{cases}$$

He has now undertaken the examination of chrysophanic acid, which appears to be similar, being dioxymethylanthraquinone. —*Ber. Berl. Chem. Ges.*, viii, 970. July, 1875. G. F. B.

10. *On the Coloring Matters Phlorein, Hæmatein and Brazilein.*—BENEDIKT has succeeded in producing from phloroglucin a coloring matter which shows a marked analogy with those of logwood and Brazil wood. This substance, which he calls phlorein, is prepared by the action of nitrous acid dissolved in nitric upon phloroglucin dissolved in ether. On distilling off the ether a magnificent violet semi-fluid residue remained, which, on adding water, was precipitated in red-brown light flocks. It was purified by reduction, and was obtained as a dark green powder with a strong metallic luster, nearly insoluble in boiling water, but soluble in alcohol, ether, and acetic acid with a deep brown, and in alkalies with an intense purple color. Owing to the difficulty of its combustion, its nitrogen was at first overlooked. The empirical formula $C_{18}H_{11}NO_7$ is assigned to it, the rational formula

founded on this, deriving it from ammonia N —

$$\begin{cases}C_6H_2\begin{cases}OH\\OH\\O\end{cases}\\C_6H_2\begin{cases}OH.\\O\end{cases}\\C_6H_2\begin{cases}OH\\OH\end{cases}\end{cases}$$

The great similarity of phlorein to hæmatein and brazilein led the author to prepare these bodies and to analyze them. He found that they both contained nitrogen, hitherto overlooked, and were otherwise similarly constituted. He writes phlorein as $3(C_6H_5O_3)N-(H_2O)_2$, hæmatein as $3(C_{16}H_{13}O_6)N$ and brazilein as $3(C_{22}H_{17}O_7)N$. Phlorein, however, yields a hydroderivative.—*Liebig's Annalen*, clxxviii, 92, Aug., 1875. G. F. B.

11. *Arithmetical relations between the Atomic weights.* Note by Prof. IRA REMSEN, addressed to one of the editors, dated Williamstown, Mass., Oct. 11, 1875.—In the last October number of the American Journal of Science there is contained an article by M. D. C. Hodges, entitled, "On the Arithmetical Relations between the Atomic Weights," in regard to which I venture to offer a remark. The subject treated in the article is undoubtedly of in-

terest, and some credit is due Mr. Hodges for his apparently independent discovery of the relations described. I think, however, that a certain amount of credit should also be given to those who first called attention to these relations.

In the Annalen der Chemie und Pharmacie (VIII Supplement, S. 133) there is a masterly article by D. Mendelejeff in which the same subject is discussed that is discussed in Mr. Hodges's paper. Every relation referred to in the latter paper is made use of in the former paper, together with a great many beautiful relations which do not seem to have occurred to Mr. Hodges.

The subject of Mendelejeff's paper is: "The periodical law of the Chemical elements." Under this head he discusses the following subjects:

(1.) The nature of the periodical law.

(2.) On the application of the periodical law for the purpose of systematizing the elements.

(3.) Application of the periodical law for the purpose of determining the atomic weights of elements which have not been studied exhaustively.

(4.) Application of the periodical law for the purpose of determining the properties of undiscovered elements.

(5.) On the application of the periodical law for the purpose of correcting atomic weights determined by other means.

(6.) On the application of the periodical law for the purpose of enlarging our knowledge of chemical structural forms.

The same subject, further, has also been fully discussed from another standpoint by Lothar Meyer, both in the Annalen der Chemie und Pharmacie (VII Supplement, S. 354), and in his work entitled: "Die modernen Theorien der Chemie."

In a work by H. Baumhauer ("Die Beziehungen zwischen dem Atomgewichte und der Natur der chemischen Elemente") another exhaustive discussion of the same subject may be found.

Mr. Hodges appears to have overlooked the above-mentioned memoirs.

12. *Compressibility of Carbonic Acid.*—Dr. Andrews, in a recent paper before the Royal Society, gives a continuation of his well known paper published in 1869, "On the Continuity of the Liquid and Gaseous States of Matter." A series of accurate measurements have been made of the corresponding temperature, pressure and volume of carbonic acid, to test the correctness of the laws of Boyle, Gay Lussac and Dalton. The apparatus employed was essentially the same as before, the chief improvement being in the method of ascertaining the volume of the gases before compression. The lower ends of the glass tubes containing the gases dip into small mercurial reservoirs formed of thin glass tubes, which rest on ledges within the apparatus. The leather washers used in packing the fine screws are now saturated with grease by heating them *in vacuo* under melted lard. The air enclosed in the pores of the leather was thus removed without the aid of water. This packing has never been known to fail in a

vessel filled with water. But with mercury it always yields after a few days, even under a pressure of 40 atmospheres. Unfortunately, the pressures must still be given as determined by an air or hydrogen manometer, as the only satisfactory method of reducing to absolute pressures would be by a mercury column, which, for the highest pressure would have to be over 1,200 feet high. Recently, however, a method has suggested itself by which it will probably be possible to measure pressures up to 500 or even 1,000 atmospheres directly in terms of a liquid column. The pressure required to produce liquefaction is given for various temperatures between 0° and 30° C., and agrees well with the results of the earlier measurements. The pressures are somewhat less than those given by Regnault, which were probably effected by the unavoidable pressure of air.

The compressibility was carefully measured at temperatures of 6·7°, 63·7° and 100°, the two latter temperatures being obtained by surrounding the apparatus with the vapor of methyl alcohol and water, and the pressure being carried to over 200 atmospheres. The results fully confirm those previously attained to the effect that its volume at high pressures and temperatures above the critical point is much less than that it should have if a perfect gas. Even at 100° the volume of 223 atmospheres is only about three-fifths of that given by the law, hence we may infer by analogy, that the critical points of the gases not yet liquefied are probably far below the lowest temperatures yet attained.

The law of Gay Lussac, while doubtless nearly true for the so-called permanent gases, is far from correct for gases at high pressures or near their critical points. The coefficient of expansion of carbonic acid under 1 atmosphere being ·0036, under 22 atmospheres it was ·0055 between 6° and 64°, and ·0051 between 64° and 100°. The corresponding coefficients for a pressure of 31 atmospheres were ·0068 and ·0059, and at 40 atmospheres ·0095 and ·0072.

A very large number of experiments were made on mixtures of carbonic acid and nitrogen, and the most important result was that the critical point is lowered by admixture with a non-condensable gas. Thus a mixture of 3 parts by volume of carbonic acid with 4 of nitrogen was reduced below −20° C. before condensation took place, even at the highest pressures. Even an addition of one-tenth its volume of nitrogen or air will materially lower the critical point. Finally, it appears that the law of Dalton is wholly incorrect at high pressures when one of the gases is not far from its critical point. This accounts for the observed anomalies in the tension of aqueous vapor when alone and when mixed with air, which are not accounted for as has been alleged by the hygroscopic action of the containing vessel. —*Nature*, xii, 300. E. C. P.

13. *Magnets formed of Iron Filings.*—M. Jamin has repeated the experiment of De Haldat, in which a brass tube was filled with iron filings and magnetized. The polarity was slight, not sensi-

bly increased when the stoppers closing the ends were tightened, and diminished slowly when sand was mixed with the filings. This observation is accurate but imperfect. In repeating it the filings were forcibly compressed by a small hydraulic press. When they begin to aggregate, the polarity is seen to augment considerably, and continues to increase with the pressure. Tubes were shown to the Academy from 8 to 10 cms. long and 3 cms. in diameter, which attract at least as many steel filings as pieces of good steel of the same dimensions. As the filings were of unknown origin some were prepared from very soft iron, perfectly reduced and without appreciable coercive force. The results were quite equal to the former. Here then is a metal which has no coercive force when it is continuous, but acquired a coercive force equal to that of steel when we reduce it to minute fragments, and then make them contiguous by pressure. Must not the polarity observed be attributed to this discontinuity? and is not the coercive force of steel to be explained by the same cause?

The distribution of the force in a magnet cannot be accounted for without regarding it as composed of rows of minute magnetic elements with opposite poles reacting on each other at a distance; and it is verified that the quantities of separate magnetism in each of them are increased by this reaction, from the extremity to the middle line (*Lamé Physique*, iii, 100). Up to the present time it seems to have been assumed that these elements are the molecules themselves; the preceding experiment seems to show that they are formed either by fragments of iron in proximity to one another, or by minute crystals agglomerated as in steel.

When before pressing the filings we interpolate among them substances which render the mass more homogeneous, the same polarity cannot be given as when they are unmixed. For example, by making a paste of chloride of iron and the filings, and rubbing it, we obtain, after a few days, a subchloride continuous in appearance, capable of being filed and polished like pure iron, but hardly magnetizable.

Iron reduced by hydrogen, and scales of oxide of iron, behave like iron filings; but magnetic and diamagnetic substances mixed with the filings alter notably the faculty they possess of being magnetized. The study of all these circumstances promises interesting researches. It is probable that by greatly increasing the compression of the powders the coercive force will be found to increase to a maximum, and afterward diminish when the approximation of the fragments has restored a sufficient degree of continuity to the mass. — *Comptes Rendus*, lxxxi, 205; *Phil. Mag.*, l, 255. E. C. P.

14. *Sounding Flames.*—M. C. Decharme finds that persistent and varied sounds may be obtained by allowing a current of air to impinge on a jet of common illuminating gas issuing from a tube 3 to 5 mms. in diameter, and forming a flame 30 to 50 cms.

high. The air is conveyed in a similar tube, and the character of the sound will vary according to the part of the flame struck, the pressure of the air and the ratio of the diameter of the tubes.

When the jet of air, striking the flame near the top, gradually descends to within about a decimeter of the orifice, we see the column of flame first divide, lower itself, then twist under the jet, envelop it and let it pass, surrounding it with a blue flickering flame; a continuous tearing sound is then heard from this luminous vail. When the jet reaches within 2 or 3 cms. of the orifice of the gas (the air tube being held horizontally and being directed toward the flame) a loud hissing is produced. Finally, when the tubes touch, the hissing becomes harsher, or if the pressure is small, becomes a very clear and agreeable musical sound.

The experiment also succeeds well with a Bunsen burner, after closing the air holes. It is needless to add that no sound is produced with the simple gas jet if not lighted. By varying the conditions, as the nature and pressure of the gas and air, the position, diameter, form and nature of the tubes, various modifications of the sounds, and of the shape and color of the flame are produced. The rapid motions are readily analyzed by a revolving mirror. It would appear that the explanation of these facts depends not merely on the mechanical, but in a great measure on the chemical action of the air.—*Comptes Rendus*, lxxx, 1602.

E. C. P.

II. Geology and Natural History.

1. *Evidence of glacial action upon the summit of Mt. Washington, N. H.*—Prof. C. H. Hitchcock has recently given the details of the discovery of transported bowlders upon the summit of Mt. Washington, 6,293 feet above mean tide water, in a paper read before the American Association for the Advancement of Science at Detroit. The following are the essential points of the communication. The bowlders do not exceed six inches in length so far as observed, and consist of the "Bethlehem gneiss" of the N. H. Reports, and must have been transported more than a dozen miles. They occur in the usual *moraine profonde* of the Northern drift and have the peculiar shapes common to glaciated stones, but do not well retain any glacial markings upon them. After observing that most of the angular blocks upon this summit rest upon this drift containing transported bowlders, the author comes to the conclusion that the greater part of the angular debris upon this mountain, though of the same material with the ledges, has been transported by the glacial agency from a few rods to three miles. Subsequently the frost has shattered them into angular fragments nearly covering the surface. Wherever ledges occur the same agency has broken off large masses which cannot be distinguished lithologically from those that may have been transported a considerable distance. Most of this angular debris is so far removed from existing ledges that frost

and gravity alone cannot have placed them where they now are though many of the piles are thus explicable. The ledges have their northwestern sides rounded and the southeast angular just like the striated bosses near the Lake of the Clouds.

Earlier observers have failed to discover these facts because the far transported stones have been brought to light by recent excavations in the earth beneath the almost universal carpet of frost-cleft fragments.

2. *Report on the Geology and Resources of the Region in the vicinity of the 49th Parallel from the Lake of the Woods to the Rocky Mountains;* by G. M. DAWSON, Geologist and Botanist to the Commission. 388 pp. 8vo, with a colored geological map, views and sections. Montreal, 1875. Addressed to Major D. R. CAMERON, R. A., H. M. Boundary Commissioner.—This volume by an excellent geological observer, contains the results of an investigation of the Rocky Mountain formations north of and near the northern boundary of the United States, and is well illustrated by sketches, sections and maps. The author speaks first of the General physical geography and outline geology of the region, and then of the special geology of the Lake of the Woods, and the structure of the Rocky Mountains near the 49th parallel.

A large amount of facts are given respecting the Cretaceous and Tertiary strata, which will aid in settling doubtful points as to the distribution of the formations and as to the age of the Lignitic beds. Chapter VIII is devoted to this last subject, "the age of the Lignite-bearing formation and position of the line separating the Cretaceous and Tertiary," and the discussion is one of value as it comes from a careful worker over a new part of the Lignitic area. Many results of assays of the lignite are contained in a chapter on its economical value. Mr. Dawson discovered coccoliths and rhabdoliths in great numbers in the Cretaceous beds of Manitoba.

Chapters IX and X, 65 pages in length, treat of the Glacial phenomena and superficial deposits of the region examined, and Chapter XI of the Capabilities of the Region with reference to settlement. Following this there are Zoölogical Appendixes, Descriptions of fossil plants by Dr. Dawson, etc.

The Glacial facts collected are numerous and of wide import. The scratches over the region of the Lake of the Woods show that the movement of the ice there was in general *toward the southwest.* The courses, stated on page 205, vary from S. 5° W. to S. 87° W.; but the larger part are between S. 20° W. and S. 40° W. The author arrives independently at the conclusion, brought out by Major General G. K. Warren, that Lake Winnipeg formerly had a southern outflow—though differing from the latter in making this pre-Glacial in time. The author, to explain the glacial phenomena observed by him, supposes that the interior of the continent was under the sea, and that local glaciers and icebergs were the chief agents. He says that "the height of the highest terraces at the South Kootanie Pass is 4,400

feet, and I have little doubt but that these are of marine origin." Mr. Dawson appreciates the objection to this view from the absence of all marine remains and of other results of marine action that might, if such were the case, be reasonably looked for. He appears to suppose that there is no alternative between the theory of marine submergence and that of a great Polar ice-cap. The facts he presents with regard to the southwest course of the glacial scratches about the Lake of the Woods in connection with similar facts about Lake Winnipeg, and Lake Huron, in Ohio, etc., point to another view more consistent with the earth's meteorological laws, viz: that the glacier had its greatest thickness not in a Polar ice-cape, but toward the Atlantic border of the Continent, where the precipitation would necessarily have been the greatest; that the upper surface of the ice sloped thence away southeastward over New England, and southwestward over western New York, Ohio, Lake Huron and the region north of Lake Superior to the Lake of the Woods and Lake Winnipeg; that it thinned down to nothing over the great central and western area between 100° W. and the Cascade Mountains of Oregon, where precipitation now averages but one-third what it is on the eastern border and summer heat is great, and had much thickness in these latitudes only in the Arctic; but that the Arctic would have had its precipitation greatly diminished by the new conditions, and hence would, perhaps, have had less ice than now; that the assumed ice-cape was rather an ice-mantle thrown about the pole and descending along the borders of the continent, especially the eastern. Add local glaciers about the mountains, the Appalachians on the east and the various higher elevations on the west, and we have all the ice that is needed to explain the facts in North America upon the basis of a Glacier theory. The above mentioned meteorological conditions would have had special intensity, if the glacial cold and the excessive glacial precipitation were due to the confinement of the Gulf Stream with its heat to the temperate and tropical North Atlantic by a shoaling of the ocean between Scandinavia and Greenland. J. D. D.

3. *Report of a Reconnaissance of the Black Hills of Dakota made in the summer of* 1874; by WILLIAM LUDLOW, Captain of Engineers, Lieutenant-Colonel U. S. A., Chief Engineer Department of Dakota. 122 pp. 4to, with several maps. Washington, 1875. Engineer Department, U. S. Army.—This volume consists of a General Report of the Expedition by Col. Ludlow; a Geological Report, with a list of Trees and Shrubs, by N. H. Winchell; a Paleontological Report, by G. B. Grinnell; descriptions and figures of new Fossils, by R. P. Whitfield (including *Obolus Pectenoides* Whitfield, from Potsdam rocks on French Creek, Dakota, *Terebratula Helena* Whitf., from the Cretaceous on the northeast side of the Black Hills); and Tables of observations for time and latitude. Of the maps in the volume one is a Geological map, by Professor Winchell, of the Black Hills on a scale of 6 miles to 1 inch. The rocks described by Prof. Winchell

are the Cretaceous, the Jurassic and Triassic or Red beds, about 325 feet thick at the northern base of the Black Hills, a limestone formation lying *unconformably* beneath the Red beds, which is Carboniferous at top and may include other formations, and the Potsdam sandstone. Beneath the last are metamorphic schists and slate with high angle of dip, and granite. We understand from Mr. G. B. Grinnell, that the credit of identifying the fossils mentioned in Prof. Winchell's Report should have been given by the latter to Mr. R. P. Whitfield, instead of to himself. J. D. D.

4. *Discovery of the Horns of an extinct species of Ox in Ohio.*—A few years ago some workmen digging in the gravel on Brush Creek, Adams County, O., preparatory to laying foundations for the abutments of a bridge, discovered a pair of enormous horns about eighteen feet below the surface. On examination it was found that they were only the *cores* of the original horns, the exterior portion having perished. They measure nearly six feet from tip to tip, and are twenty-two inches in circumference. As the core of the horns of the ox is about one-third of the entire length, these must have been of enormous size. They were sent to Cincinnati, and have been kept in comparative obscurity until quite recently, when they came under the observation of Dr. Norton, who obtained permission to exhibit them before the Natural History Society. The Society has since secured them.

5. *On the Mesozoic formation of Mexico and its characteristic fossils;* by MARIANO BARCENA. 37 pp. 8vo. Mexico, 1875.—In this Memoir (in Spanish) Mr. Barcena treats of the distribution of the Cretaceous rocks of Mexico, their kinds and their fossils. The rocks include limestones, part of them metamorphic, different argillaceous rocks, micaceous, talcose and dioritic rocks, and they are stated to constitute a large part of the mountain elevations of the Mexican territory. The gray, compact limestones contain species of *Hippurites* and *Nerinea* in so great abundance that they are well called the Hippurite limestone and Nerinea limestone of Mexico. The author describes and figures two species of Hippurites, *H. Mexicana* and *H. calamitiformis*, several species of Nerinea, and also species of Ammonites and Scaphites, and an Aptychus, *A. Arenassii*. The reasons for referring the rocks of different districts to the Cretaceous, and especially to the Upper Cretaceous, are given at length by Mr. Barcena, in the course of his Memoir. From the evidence it is concluded that Cretaceous rocks occur in all the Mexican States; and the author consequently proposes that the map of North America in the Cretaceous period, which is given in Dana's Manual of Geology should be changed, by making the area of Cretaceous seas to extend from Texas westward to the Pacific Ocean—the facts serving to prove that the Gulf of Mexico and the Pacific were actually connected in the Cretaceous period. The Cretaceous area thus added, as shown on a map accompanying the Memoir, lies between a line from the Pacific to the Gulf, northeast in course, running nearly through Chihuahua, and another parallel through Vera Cruz. Its extension northwestward and southeastward remains for future determination.

Mr. Barcena in another paper, published at Mexico in 1875, describes a fossil Sphæroma—*S. Burkartii*—from the valley of Ameca, Estate of Jalisco, which was obtained in an Artesian boring from beds that are probably Tertiary. No other fossils have been found at the place to fix the age; a figure of the species accompanies the paper. J. D. D.

6. *Mountain Making: The inequalities of the Earth's Surface viewed in connection with Secular Cooling.*—Mr. O. FISHER closes a mathematical discussion of this subject in the Cambridge Phil. Trans., vol. xii, part ii, with the following remarks:

Can we then attribute the intense corrugations which meet our observation to any other source than that of lateral pressure caused by a shrinking globe? It appears to me difficult to conceive any other. No local change in the condition of the superficial strata seems competent to produce a sufficient amount of extension in the superficial strata. I cannot perceive, as I have already endeavored to explain, how the deposition of thick beds upon the sea-bottom could affect it by their weight, and I have elsewhere, I think proved, that they could not do so by causing a new distribution of heat within the crust.* There is likewise much reason to believe that consolidation and metamorphism are accompanied by a contraction in volume.

The supposition that the earth became solid throughout, or nearly so, before a crust began to be formed, necesitates the consequence that the contraction, out of which the compression would arise, must be almost wholly confined to the cooled upper portion: it is upon this supposition that we have calculated its amount, and found it so much smaller than is warranted by natural appearances. If, however, we could suppose that a solid crust was formed upon the surface, long before its interior parts had fallen to the melting temperature, it seems that a much greater amount of compression might result, through the contraction extending far below the cooled upper portion. The objection made to this is, that the crust would break up as fast as it formed, and sink into the underlying fluid until the whole was brought to the melting temperature. But Mr. Mallet has shown, in the paper already more than once referred to,† that the difference between the specific gravities of solidifying and molten rock is so small, being scarcely six per cent, that when we consider the intermediate condition of viscosity, we need not assume this breaking up and sinking of the crust. And if in its early stages shrinkage cracks did form, it seems likely that the fluid which welled up into them would immediately solidify and seal them up. Scrope tells us that "the interior of a lava-stream often retains a very high temperature for a great length of time after its emission, continuing to send forth vapor from its crevices and fumeroles, and probably remaining liquid, and even more or less in motion, throughout its central and lower portion for years.‡"

* Geographical Magazine, vol. x, p. 248. † Phil. Trans. 1873, p. 160, § 50.
‡ Volcanoes, 2nd edition, p. 84, § 8.

Sir W. Thomson clearly contemplates the mode of solidification from without inwards as not impossible, for he says "If experimenters will find the latent heat of fusion and the variation of conductivity and specific heat of the earth's crust up to its melting point, it will be easy to modify the solution given above so as to make it applicable to the case of a liquid globe gradually solidifying from without inwards in consequence of heat conducted through the solid crust to a cold external medium."

If this supposition is admissible, there may have been a considerably larger nucleus enclosed within the crust in early times than we have at present, and a great portion of that nucleus may have consisted in superheated water, the rocks being in a state of igneo-aqueous solution:* and much of this water may have been blown off in steam during volcanic eruptions, by that means materially contributing to the diminution of the volume. I have suggested in my former paper read before this Society, that Mr. Sorby's observations on the water enclosed in granitic crystals, along with crystals of chlorides, renders it probable that the steam emitted in eruptions may be a constituent part of the deep-seated rocks, for it is probable that but a small part of the water contained in any magma would become confined in the interior of the crystals.

Here, however, the question arises whether it would be possible for a crust to form over a layer of molten rock in a condition of igneo-aqueous fusion. Would not the escape of the water cause a state of constant ebullition which would prevent the formation of any crust until it had ceased through the escape of water?

The idea of igneo-aqueous solution involves a condition of chemical combination between the water and the elements of the rock such that while that condition lasted there would be no tendency to separation between the two, and evaporation would be in abeyance. We can therefore conceive that at depths where the heat and pressure were sufficient there might be no tendency to evaporation and consequent ebullition, so that after the water had escaped to a certain depth ebullition would cease, and a crust be formed; but that more water would be ready to separate to a greater depth when its affinity for rock became lessened through the abstraction of heat, or diminution of pressure owing to the crust being partially supported by corrugation.

* The following remarks upon the above passage were received from a quarter which disposes me to place great reliance on them:

"It is probable, or rather certain, that water substance, if it exists at great depths under great pressure and at high temperature, is neither a gas nor a liquid, being above its critical point.

"In this state substances are easily dissolved in it, not however so much on account of a greater tendency to combine with water, as on account of a greater tendency of their own to dissipation. At still higher temperature the water substance becomes itself dissociated into oxygen and hydrogen. But it does not follow that the dissolved substances will be precipitated. The magma may be all the more complete the higher the temperature, because, though the bonds of affinity have fallen away, the prison-walls prevent the elements from escaping. But of all the known regions of the Universe the most unsafe to reason about is that which is under our feet."

If such was the condition of the interior in the early stages of the cosmogony, a large portion of the oceans now above the crust may once have been beneath it, and thus we gain a novel conception of a sense in which the fountains of the abyss may once have been broken up.

A somewhat analogous escape of elastic vapor from beneath a denser envelope is I believe considered to be now taking place in the Sun.

The comparative small specific gravity of the earth as a whole, considering the great pressure to which its interior parts must be subject, has been held to prove that it is even now in a state of expansion through intense heat.*

But the question of its true condition is surrounded with difficulties. The supposition made by Sir Wm. Thomson of a cool nucleus covered by a sufficiently deep layer of molten rock is adopted by Dr. Sterry Hunt,† and would afford the conditions required by the argument of this paper. It would also afford the mean rigidity required to meet the objection to a fluid interior drawn from the absence of internal tides. But it would not account for the small specific gravity of the whole, nor yet would it meet the argument from precession in the form in which it was originally advanced by Mr. Hopkins: for a layer of fluid beneath the crust would destroy a rigid connection between it and the interior. This form of the argument however has been attacked, and apparently with some success.‡ The late Archdeacon Pratt, in defense of the general argument from precession, placed the matter in a simple light in a letter to *Nature* in 1871,§ and in that form I think it would be met by the supposition of a cool nucleus covered by a molten ocean with a solidified crust. But I would invite attention to the fact that the conclusions I have arrived at, concerning a highly fluid condition of the interior, have reference to an early period of its history; while the tests of the tides, and of precession, are confined in their application to the present. Nevertheless I am disposed to think that, at any rate, what may be termed a superheated condition of the mass still exists at no very great depth below the surface. By which I mean that if it be solid the solidity is due to pressure.

7. *Remarks on the Sedimentary Formations of New South Wales;* by Rev. W. B. Clarke, M.A., F.G.S., &c. Third edition, 62 pp. with geological sections. Sydney, New South Wales, 1875. —This memoir is a review of the geology of Australia by one who has worked long in geological investigations over New South Wales. The question of the age of the coal formation is fully discussed; and between the extreme limits adopted by different writers, the Jurassic period and the Lower Carboniferous, Mr. Clarke holds to his old opinion that they are of the latter age.

* Herschel's Phys. Geography, 2nd edit., p. 7.

† American Journal of Science, vol. v, p. 264.

‡ General Barnard on "Problems of Rotary Motion," Smithsonian Contributions, No. 240.

§ Nature, vol. iv, p. 344.

The writer in his Exploring Expedition Report (1849), on New South Wales, sustained the view that their age was half way between those extremes, or Permian, and this is adopted by him in the last edition of his Manual of Geology (1874, p. 370). The absence of Tertiary rocks from all of Eastern Australia is accounted for on the supposition that the eastern coast, since the Tertiary era, has subsided many fathoms, as indicated by the existence of the great barrier coral-reef off the coast, any Tertiary formations then formed having been thus submerged. J. D. D.

8. *Geological Survey of Brazil.*—Prof. C. F. Hartt, recently of the Cornell University, has been placed in charge of the Geological Survey of Brazil by the Emperor. It is reported that the survey is to be continued four years. Professor Hartt's previous explorations in Brazil, first in connection with the Thayer Expedition, have eminently fitted him for the work.

9. *Geologische Beobachtungen auf Reisen im Kaukasus*, von H. Abich. 138 pp. 8vo, with one chart. Moscow, 1875.—Prof. Abich, who has long been investigating the country of the Caucasus, here treats of the Geology of the Beschtau warm-spring formation; the North Caucasus Jurassic Coal formation; the Quartz-trachyte formation of Tschegem; and the Glaciers of the northern side of the Caucasus.

10. *Old beach on the Isle of Portland, near Weymouth, Southern England.*—Professor Prestwich describes a raised beach on the east side of the Portland Bell, its south extremity, from 24 feet to 36 feet above the present beach, near its northeastern extremity, and 53 feet at its northwestern. It contains numerous marine shells, the most of which are those of the adjoining seas, while a few belong some degrees farther north. The raised beach is capped by other beds of loam and rubble, in places 5 to 10 feet thick. At the Admirality quarries, about 400 feet above the sea, a bed of drift has afforded some bones of Mammals — *Elephas antiquus* and *E. primigenius*, and species of *Equus*, *Cervus* and *Bos*. Prof. Prestwich closes his paper with a discussion of the geographical conditions under which the deposits were made.— *Q. J. Geol. Soc.*, Febr. 1875, p. 29.

11. *Another New York Mastodon.*—A skeleton of a Mastodon has been found at Lisle, near Binghamton, New York, and is being exhumed for the Museum of the Cornell University.

12. *Microscopical Structure of Rocks*, with plates 7, 8; and *Granitic and other Ingenite Rocks of Yar-Connaught and the Lower Oxle*, with plates 9 to 12, and other papers; by G. H. Kinahan. From the Proceedings of the Roy. Irish Acad., II, vol. ii, Dublin, 1875.—These papers contain valuable facts on the nature and microscopic structure of the rocks referred to in the title. The term *Ingenite*, meaning "born, bred, or created within or below," is from a paper, on *the Microscope in Geology*, by Mr. D. Forbes, published in the Popular Science Review for October, 1867.

13. *Elemente der Petrographie*, von Dr. A. von Lasaulx, A. ö. Prof. Min. Univ. Breslau. 486 pp. 8vo. Bonn, 1875. (Emil Strauss).—

The descriptions in this work by Dr. Lasaulx are clear and concise, and generally include one or more chemical analyses. The classification is based first on (I) the fact of one mineral constituent, or (II) many; and, under these heads, on texture, as noncrystalline or crystalline, etc. An introductory portion reviews the structure of rocks, and the character of their constituent minerals, and a closing chapter treats of the origin of rocks and meteorites. The work is handsomely printed on fine paper.

14. *Minerals of Bourbonne-les-Bains.*—In addition to the mineral species of these hot waters mentioned on page 228 of this volume, Daubrée has detected also the rare species *phosgenite* (chloride of lead), covered with a crust of mixed galenite and gypsum; and, from the interior of a tube of bronze, a coating consisting of *atacamite.*—*L'Institut*, Aug. 4.

15. *Mineralogische Mittheilungen;* von V. Ritter v. Zepharovich, VI, 1875.—This sixth number of the mineralogical contributions by Professor Zepharovich contains descriptions of crystals of aragonite from Eisenerz and Hüttenberg, of native arsenic from Joachimsthal, and a discussion of the crystalline form of cronstedtite. The aragonite crystals were remarkable in exhibiting a large number of planes, mostly in the prismatic zone, with abnormal fractional indices, analogous to those long since described by Websky. E. S. D.

16. *Wiserine is Octahedrite.*—Professor Klein, of Heidelberg, in a recent valuable memoir on the crystallization of anatase (octahedrite) has shown that the wiserine (xenotime) from the Binnenthal, described by Kenngott, is actually identical with octahedrite. He remarks, however, that true xenotime is found at that locality, but the crystals do not agree with those described as wiserine.—*Jahrb. Min.*, 1875, 337. E. S. D.

17. *Chalcophanite, a new mineral;* by Gideon E. Moore, Ph.D. —Occurs in druses of lustrous crytals, and in foliated aggregates, lining the walls of cavities or grouped in stalactitic forms; in the latter case the crystals are grouped around a central core of a manganiferous mineral. The crystals are minute, but occasionally sufficiently distinct to admit of determination. Rhombohedral; occurring planes O and R, the basal plane preponderating, the crystals are sometimes in the form of thin scales. Measurements gave for $R \wedge R$ 114° 30′, and $O \wedge R$ 104° 13′ (required 103° 48′), whence a=3·5267. Basal plane brilliant, rhombohedral faces often deeply striated. Cleavage, basal perfect; micaceous, the thin laminæ slightly flexible. H.=2·5. G.=3·907. Luster metallic. Color bluish-black to iron-black. Streak chocolate-brown, dull. Opaque. Before the blow-pipe turns to a yellowish-bronze or copper-red; exfoliates slightly, and on continued heating darkens in color, and fuses slightly on thin edges. With the fluxes gives a strong maganese reaction, and on charcoal with soda gives a coating of oxide of zinc. Soluble in hydrochloric acid.

Analyses: 1, of distinct crystals; 2, of stalactitic aggregates possessing a radiated structure. In the latter case the material was not so pure as that used in analysis 1.

		$\dot{M}n$	$\dot{M}n$	$\dot{Z}n$	$\dot{F}e$	$\dot{H}$
1.	$\frac{3}{4}$	59·94	6·58	21·70	·25	11.58=100·05
2.	$\frac{1}{2}$	61·57	4·41	20·80	—	12·66

Analysis 1 gives for the oxygen ratio of peroxide, protoxides and water 4 : 1 : 2, and the same is obtained from 2 after making deductions for impurities present. This ratio gives for the formula $\dot{R}$, $\dot{R}_2 + \dot{H}_2$, or more exactly ($\frac{1}{4}\dot{M}n$, $\frac{1}{4}\dot{Z}n$), $\dot{M}n_2 + 2\dot{H}$. In this case one-half of the water is regarded as basic. It is thus closely related to wad and psilomelane.

Chalcophanite is a result of the decomposition of franklinite and associated minerals. Found at the calamine locality at Stirling Hill, Ogdensburg, N. J.

Named from *χαλκός* brass and *φαίνω* to appear, in allusion to the change of color which the mineral undergoes upon ignition. —*Am. Chem.*, July, 1875. E. S. D.

18. *Statistics of Mines and Mining* (*Sixth Annual Report*); by Rossiter W. Raymond, U. S. Commissioner of Mining Statistics. 8vo, pp. 585. Washington, 1874.—Dr. Raymond's Reports on the Mines and Mining in the States and Territories west of the Rocky Mountains now form a most valuable repository of scientific and technical literature on all topics germane to this subject. The present volume contains the usual data respecting the mining industry of the ten States and Territories enumerated for the year 1873, together with special chapters on the following subjects:—the Mining and Metallurgy of Quicksilver; Hints on the Washoe process; Smelting in Park County, Colorado; Lead and Silver Smelting in Chicago; the Wyandotte Smelting and Refining Works; the Smelting Works of the Harz; the desilverization of Lead by Zinc; avoidable Wastes of American Smelting Works; Kustel's Roasting-furnace; Brückner's Cylinders; a Metallurgical Laboratory; Sinking Shafts with the Diamond Drill, &c.

These reports have become an acknowledged authority on the subjects which they treat, and are remarkable for fairness and accuracy of statement. They have for years been quoted and discussed, and in a large part translated in Germany, where the general features of our western mining industry are almost as widely known as they are in this. Thence, many skilled metallurgists, mining mechanics, and men otherwise scientifically trained, have been drawn to this country as permanent residents, greatly to our advantage. B. S.

19. *The formation of Starch* in chlorophyll-grains (in the green parts of plants), under the action of light, was made out by Sachs ten or twelve years ago, and has been confirmed, and the conditions recently studied in various ways by Famintzin, Kraus, and Godlewski. It is maintained, if we rightly understand, that this starch is directly formed from carbonic acid under the action of light, i. e., is a primary product of assimilation. Böhm, of Vienna, who contested this, but whose view according to Sachs "has already been sufficiently refuted," has returned to the sub-

ject, with new observations and experiments, now asserts, upon reasons stated, that

"The starch appearing in the seed-leaves of plantlets of Cress Radish and Flax, is not a direct assimilation-product, formed by the immediate decomposition of carbonic acid, but a transformation-product from a reserve of nutriment already present."

One would surely expect that the primary product of assimilation of carbonic acid and water would be an organizable plasma from which the starch-grains in question are constituted, not an organic structure such as a starch-grain is. It is not clear that there is much real difference between the two views, at least between those of Sachs and Böhm. For since starch, as the former explains, is formed and reformed in various parts of the plant and away from light and from chlorophyll, and in the leaf is allowed to be only one of the products of assimilation, Sachs' assertion that starch in chlorophyll-grains is "a product of assimilation," and Böhm's that it is "not a direct assimilation-product," are by no means in necessary contradiction. Nor is there apparent reason for supposing that a starch-grain in a potato-leaf is differently originated from one in a potato, except that the former is constructed of new-formed material. A. G.

20. *A Report on the Trees and Shrubs growing naturally in the Forests of Massachusetts;* by GEORGE B. EMERSON. Second edition. Boston: Little, Brown & Co., 1875. 2 vols. 8vo; with many plates.—The original edition, published in 1846, agreeably to an order of the Legislature by the Commissioners of the Zoological and Botanical Survey of the State, was a single volume, of 534 pages, to which 17 outline plates were added, the first drawing of the kind by Mr. Isaac Sprague. It was a classical work, of so great use and value, that the edition (we believe a large one) was soon exhausted. Author and artist still flourishing, and the zeal and public spirit of the former unabated, a new edition now appears, re-elaborated, enlarged, and amply illustrated, forming two volumes, which reflect great credit upon author, artists, and printer. There are 143 plates; and many of those from Mr. Sprague's drawings are colored chromoliths, more effective and truthful than any which we remember to have seen before. Several which exhibit the winter state of some of our deciduous trees are full of character. The introduction of scenic views of many foreign, mainly European trees, copied from various sources, adds a novel feature. Those who plant trees, and the many more who ought to be planting them, will value these attractive pictures the more, since they mainly represent well-grown specimens of trees which are known or may by expected to thrive in this part of the country. Some of them, from Figuier's Vegetable World, border a little on the sensational or factitious. The only one we are disposed to find much fault with stands in the place of honor, fronting the title-page, "*Sequoia gigantea*, or Giant Pine of California." Why should it be called a Pine? Cypress would be nearer the mark if any of the old

common names need to be used. And why should the tree have a wall of the Yosemite Valley for a back-ground, since Mr. Emerson well knows that it does not grow there, however it may be with M. Figuier and his artist, Faguet. Through some oversight, in our copy, a plate, evidently representing the Black Oak, does supernumerary duty for Red Oak, which has two good plates of its own, one for the acorns and leaf, another for the port of the tree. There is a good figure of *Salix petiolaris*, but no letterpress. The severance of the long-standing connection between the Weeping Willow and Babylon, which has been referred to in this Journal, has escaped the venerable author's attention. We may be permitted to find some fault to relieve the monotone of praise which this attractive book calls forth. If space permitted we would call particular attention to the new part of the Preface, with its remark that, in the author's own experience upon our sea coast, European Oaks, Beech, Linden, Maple, Elm, Ash, Mountain-Ash, and Pine, are "more hardy than the corresponding American trees," and its warning close from Bryant's early poem, as well the important chapter on the uses, continuation and improvement of our forests. A. G.

21. *On the Classification and Sexual Reproduction of Thallophytes;* by W. T. THISELTON DYER. An article of 33 pages 8vo, revised and reprinted from the Quarterly Journal of the Microscopical Society, London, July, 1875.—A timely and good *resumé* of all the important recent contributions to our knowledge of this subject, based upon the fourth edition of Sachs' *Lehrbuch*, with historical and critical discussion. The result is the provisional adoption of Sachs' classification, in which *Algæ*, *Fungi*, and *Lichens*, are relegated to the past, all Thallophytes are arranged in two parallel series, one with chlorophyll (*Algæ* and *Characeæ* of old) and one without, the latter being to the former nearly what *Monotropeæ*, *Orobancheæ*, *Cuscuta*, and the root-parasitic orchids are to the orders they respectively pertain to, or are parasitic representatives of; and the classes they are arranged under in a double series, viz: *Protophyta*, *Zygosporeæ*, *Oosporeæ*, and *Carposporeæ*, founded on characters of reproduction alone, and rising in increasing complexity and differentiation in the order indicated above. The green series begins below with the *Cyanophyceæ*, followed by the *Palmellaceæ*, and ends with *Florideæ* followed by *Characeæ*. The parallel *Fungi*-series begins with the *Schizomycetes* (Bacterians) followed by the *Saccharomycetes*, and these by the *Zygosporous Myxomycetes* and *Zygomycetes*, and ending with the *Ascomycetes*, under which are placed the *Lichens*, and finally the *Basidiomycetes*. This arrangement being "according to their morphological complexity," is thought to shadow forth, to a certain degree or with some probability, the "phylogeny" of the lower orders of the vegetable kingdom, although not with any strict genetic signification. As to this degradation of the *Lichenes*, it is remarked that the general result of the later investigations has been, on the whole, confir-

matory of Schwendener's view. A history of our knowledge of sexual reproduction in plants, and more particularly, of cryptogamous plants, occupies two or three of the earlier pages. To Thwaites is attributed the origination of the view that conjugation is sexual reproduction in its most generalized form. It seems strange that any different view could have been supported; but it is not so very long ago that it was maintained by Mohl. Thwaites and Jenner, as early as 1848, inferred "an apparent adumbration of the sexes" in *Zygnema*, &c., from the formation of the spore in the cells of one of the wholly similar parents, instead of between the two as in *Desmidieæ* and *Diatomaceæ*, but such adumbration is rather "apparent" than real. It was Thwaites who, in 1847, discovered conjugation in *Diatomaceæ*. Morren had long before discovered it in *Desmidieæ* (*Closterium*). The cilia of antherozoids were discovered in 1840, by Thuret, whose recent death, in the midst of important work, botanists may well deplore. In 1852 Thuret first obtained actual fertilization by the antherozoids in the case of *Fucus*. A. G.

22. *Monographie der Juncaceen vom Cap*, bearbeitet vom FRANS BUCHENAU. Bremen, 1875. 8vo.—This monograph of the *Juncaceæ* of the Cape of Good Hope, by Dr. Buchenau, is a separate issue from the *Abhandlungen des naturwissenschaftlichen Vereins zu Bremen*, Band iv, Heft 4, pp. 393–512, and is illustrated by 7 quarto plates, filled with details, devoted to the illustration of 32 species, chiefly of the genus *Juncus*. At the close is given a *resumé* of the literature of the South African *Juncaceæ*, from the Supplementum Plantarum of the younger Linnæus down to Steudel's Synopsis of *Glumaceæ*. Also names are given to the numbers in Drège's distributed collection. A. G.

23. *Elements of Zoology;* by SANBORN TENNEY. 8vo, 503 pp., with 750 wood-cuts. New York (Scribner, Armstrong & Co.) 1875.—In this work the author has attempted to give an outline of the Animal Kingdom by describing the larger groups, down to the orders and sub-orders. The principal characters of the classes are given with considerable fullness, in most cases, together with a summary of the orders or other subdivisions into which they are divided, and then each of the orders or sub-orders is briefly characterized and illustrated. The author has, in most cases, given under each class not only the classification that he adopts, but one or more of the different classifications that have been proposed by some of the leading writers on zoölogy. This feature will much increase the value of the work as a convenient book of reference, and will, perhaps, enable many teachers to use it as a text-book who may not wish to adopt the classification preferred by the author. The illustrations are very profuse and are, for the most part, well chosen and much superior in their execution to those ordinarily seen in similar text-books. This collection of figures would of itself render the work a very useful and valuable one for the use both of students and teachers. About five hundred of these cuts have been previously used in the

author's Manual of Zoölogy, and the two hundred and fifty additional ones have been selected from various other works. A list of the cuts is given, with the origin of each, which is a very commendable feature. The descriptions of the characters of the various groups are generally correct, though often rather too brief, and perhaps for this reason the statements are sometimes so general and indefinite as scarcely to be easily understood by beginners. It is natural, also, to expect positive errors in all works of this kind, for no one person can be familiar with the whole range of zoölogical science, as developed in recent times. We have noticed a few such errors in the work before us. Thus on pages 374 and 380 the well known Holothurian genus *Synapta* is included among the Gephyreans, an error so obvious that it would seem to have been accidental. A more serious error occurs on pages 216 and 227, where *Mosasaurus* and the allied genera are included among the Enaliosauria. On page 242 there is a confusion of ideas, although most of the facts are correctly stated, but the ordinary and normal larval state (Siredon-stage) of salamanders belonging to the genus *Amblystoma*, and many others, should not be confounded with the adults of genera like *Proteus* and *Menobranchus*. Yet, notwithstanding a few defects, we consider this the most useful manual of general systematic zoölogy that has hitherto been published in this country. V.

24. *First Book of Zoology;* by EDWARD S. MORSE. 12mo, 188 pp. 158 cuts. New York (D. Appleton & Co.) 1875.—In this little volume Prof. Morse has put, in a very simple and attractive form, a surprising amount of zoölogical instruction, such as beginners desire and need to have. The numerous figures are good and well chosen, and most of them are new and drawn from native animals by the author. They are mainly in outline and the author judiciously recommends learners to copy them in all cases, but if they should go farther and draw some of the real animals or their parts it would be still better. The book is devoted wholly to the Mollusca, Insects, Crustacea and Annelids, with a short but useful chapter on Vertebrates. The Protozoa, Radiata, Polyzoa, Brachiopoda, Tunicata, Cephalopoda, and most of the "Vermes" are not mentioned, the design being to describe those groups of animals that young students can most easily obtain for examination. Scientific names are wholly omitted, and although to many this may appear to be an advantage, we imagine that some indication of the name of each species figured, even in a list of figures at the end of the volume, would have considerably increased the value and usefulness of the book, both for pupils and teachers, for however little value we may attach to mere names, most persons, and especially young pupils, are generally anxious to know the names of animals that they may see, and read about, or at least to know whether they really *have* names, of which there is here no intimation, in most cases, and we fear that the majority of teachers and parents who may wish to use this book in teaching will hardly be able to give the missing

names of most of the figured species, which the author could so easily have supplied.

The style is clear and simple, and the descriptions are generally accurate, though brief. We have noticed but few errors worthy of note, and these will doubtless disappear in a second edition. In the figure of the mouth-parts of a craw-fish, on page 136, a superfluous appendage is given to the inner side of the mandible, and on page 147 the "*cervical suture*" of the carapax is erroneously said to represent "the dividing line between the head and thorax," which would be an absurdity, considering that the carapax is an outgrowth from the third and fourth (antennary and mandibular) cephalic segments. In the last part of the book the definitions of some of the classes and other groups are faulty, as for example, in case of Arachnida on page 185, where the definition would exclude a large proportion of the species belonging to it, as it really applies to but two of the four orders. The same may be said of the definition of "Vermes" both on pages 185 and 160. But there is much in the book that will be of interest and useful, even to advanced students. The chapter on the bones of the leg and wing of birds is particularly valuable. v.

25. *The Bones, Ligaments, and Muscles of the Domestic Cat;* by H. S. Williams. *With an atlas of photo-lithographic plates, reduced from those of Straus-Durckheim.* New York, (G. P. Putnam's Sons.) 1875.—The text of this work forms a small volume of 86 pages, devoted to the explanation of the accompanying plates. It is essentially a translation of the original explanations of Straus-Durckheim, with such revisions as the author has thought necessary, and with the substitution of Latin names of the parts for the original French terms. The plates have been well reduced by the Osborne photo-lithographic process to a small folio size, and correspond to the outline plates, 2 to 13, of the original work. The work is intended as a reference book for use in the practical study of comparative anatomy, and for this purpose will doubtless prove very useful, as it can be sold at a price that will bring it within the reach of all students, while the original work is costly and quite generally inaccessible in this country. We understand that Dr. Williams proposes to issue additional volumes with similar reductions of the plates illustrating the anatomy of the viscera and other organs. It is to be hoped that he may soon accomplish this, for in most cases it is quite as important, or even more so, that students should thoroughly study the digestive, circulatory, respiratory, and nervous systems, as the bones and muscles. v.

26. *Distribution of the Alcyonoid polyps of the Umbellularia group.*—The Umbellulariæ have been found

Off the coast of Greenland in 236, 410 and 121 fathoms.

In the *Atlantic* by the Challenger Expedition: (1) between Cape St. Vincent and Maderia, 35° 20′ N., 134½° W., in 2,125 fathoms; (2) 300 miles to the eastward of the St. Paul's rocks, 1° 47′ N., 24° 26′ W., in 1,850 fathoms; (3) off Brazil, 10° 11′ S., 35° 22′ W., in 1,600.

In the Antarctic by the Challenger Expedition: (1) between Prince Edwards' and the Crozet Islands, 46° 46′ S., 45° 31′ E., in 1,375 fathoms; (2) 84 miles to the westward of Hog Island, one of the Crozets, 46° 16′ S., 48° 27′ E., in 1,600 fathoms; (3) near the ice barrier, 62° 26′ S., 95° 44′ E., in 1,975 fathoms; (4) north of the ice barrier, 53° 55′ S., 108° 35′ E., in 1,950 fathoms; (5) south of Australia, 42° 42′ S., 34° 10′ E., in 2,600 feet; (6) also in the Pacific, southwest of the Louisinde group, in 2,440 fathoms.

The Umbellulariæ are usually associated with such deep sea animals as *Ophiöglyphæ*, *Brisingæ*, *Pourtalesiæ*, *Ananchytids*, *Munopsids*, *Petalophthalmi*, *Gnathophausiæ*, *Macruri*, *etc.*—*R. V. Willemoes-Suhm in Ann. Mag. N. H.*, IV, v, 312.

III. Astronomy.

1. *Observations de Poulkova ;* publiées par Otto Struve, Directeur de l'Observatoire Central Nicolas, volume vi. *Observations faites au Cercle Méridian*, S' Petersbourg, 1873, folio, pp. v and 545.—Among the most important astronomical publications of the past few years, must be enumerated the magnificent series of volumes published at Poulkova, one of the beautiful suburbs of St. Petersburg, by the Imperial Central Astronomical Observatory. The sixth volume of this series which contains the observations made from 1840 to 1855 by means of the Repsold meridian circle, has recently been received in this country. The number of observations contained in this single volume amount to 21,000, and appertain to the stars from the first to the sixth magnitudes, situated between the north pole and 15° of southern declination. The whole series of meridian circle observations will require still another volume, the seventh, and have been amassed through the labors of Sabler, 1840 to 1854, Döllen, 1844 to 1849, Lindhagan, 1854 to 1855, Winnecke, 1858 to 1864, and Gromadski, 1866 to 1869. Through the whole of this long period, no important changes have been made in the construction of the instrument, and but few changes in the methods of observation. The computations have been executed within the past few years under the successful direction of Wagner and Von Asten. C. A.

IV. Miscellaneous Scientific Intelligence.

1. *Journal of the Scottish Meteorological Society*, with Tables for year ending 31st December, 1874. Published quarterly. July, 1874—July, 1875. (William Blackwood & Sons, Edinburgh and London.)—This number of the Scottish Meteorological Journal contains, among its papers, a very important memoir on the influence of weather on mortality from different diseases and for different ages, by Mr. Alexander Buchan and Dr. Arthur Mitchell, extending to 80 pages. The enquiry embraces the three decades from 1845 to 1874 inclusive; and the Registrar-General's weekly reports of deaths in London are the basis of the

curves in the diagrams, the reports being full and the deaths all having taken place under one climate. To construct a curve for the deaths by any disease an average weekly death-rate of 20 is stated to be required. In connection with the tables of diagrams for each disease, there are meteorological reports for the same period.

It appears that in London the deaths from all causes for the 30 years, had their extreme maximum in December and January; that with the beginning of April there commenced a long decline in number to the extreme minimum in June; then began a rise to a second lower maximum in the latter half of July, continued through the first half of August; and then a decline to another minimum in October, after which the rise toward the December maximum began.

The following are some of the facts indicated with regard to deaths in London: The death-rate for scarlatina is low for March, April, May, and high for October and November; for whooping cough, high from February, March to April, and low for September and October; for typhoid fever, low for May, June and early July, and high for November and late October; for dysentery and diarrhœa, low for January and June, and very high in the latter half of July and August; for bronchitis, pneumonia and asthma, high in December, January and February, with the extreme in January, and low from June to October; by suicide, maximum from April to the last of June, and an extreme minimum in the early part of February. These cases and those of all other diseases of which the deaths were sufficiently numerous are exhibited in the diagrams.

The paper next takes up the question of deaths and their diseases during six sections of the year distinguished by differences in temperature and dryness; then the influence of weather on deaths at different ages, showing one maximum for children under one year in the latter half of July and beginning of August, and another higher in December, January and February, while for individuals above one year only the latter maximum is distinct. Afterward the influence of weather on the mortality of the two sexes is illustrated, bringing out a maximum for both in December, January, and the latter part of March, a minimum for both in June, a second maximum in the latter half of July and first half of August, and a second minimum in October, with the winter maximum higher, and the summer minimum lower, for females than for males. Another table shows that, deducting the deaths from bowel complaints, there is no summer maximum for deaths by all other diseases, but instead a continued minimum which is greatest in July and August. The diseases which are like bowel complaints in having their maximum in summer, are shown to be jaundice, tabes mesenterica, enterites, thrush, atrophy and debility. The article closes with four long tables; Table I, showing the different diseases for each year, together with a column stating the population of London; Table II, giving the mean weekly death rate

on an average of the 30 years for each of the different causes of death; Table III, showing for the different diseases and other registered causes of death for the 30 years the *percentages* of *excess* or *defect* of the death-rate of each week of the year as compared with the general average of the 52 weeks; and Table IV, showing the average death-rate *at different ages* from all causes.

2. *Voyages a la Cote Nord-Ouest de l'Amérique exécuté durant les Années*, 1870–72; par ALPH. L. PINART. Vol. I, Partie I, Histoire Naturelle. Paris, 1875. 4°, pp. 51, with plates A to E.—Mr. Pinart has devoted himself to the self-imposed task of exploring the Northwest Coast of America, with special reference to the ethnography of the tribes inhabiting Alaska and the Aleutian Islands. The author, being himself especially devoted to ethnographical and linguistic studies, has sought, in this part of his beautiful work, the aid of men eminent in their own departments in working up the natural history materials collected by him. M. Jannettaz, President of the Geological Society of France, has prepared the catalogue of geological specimens and observations on them; M. Léon de Cessac has made the Microscopical and Chemical analyses of some of the rocks of Alaska; the Paleontology is prepared by M.M. Gaudry and P. Fischer; and the Zoology is by Fischer, E. Perrier and P. Gervais. The author proposes to issue three volumes of this series, each to contain six parts similar to the one now issued. He has favored us with a sight of the plates illustrating the ethnology of his voyage, which he has enriched by researches during three winters in St. Petersburgh, where the extended collection made by the missionaries of the Greek Church, during a century or more, were liberally placed at his disposal by the Russian Government. Having completed the manuscript, and left the execution of the work to his publisher, he is again about entering on a new exploration, under a commission from the French Government, having for its object the study of the ethnology and languages of the southern races of the west coast of both North and South America. After visiting Washington he plans to go to San Francisco and thence by the coast to Valparaiso, with a view of determining if possible, besides other things, the source and direction of migration of the native American tribes of both hemispheres. Fortunately for science, M. Pinart is willing to devote his time and ample private fortune to these researches. His Government has encouraged him by giving him a commission which requires him to report specially upon certain points with reference to the Central American States, with which his former voyages have already made him familiar. B. S.

3. *General Index of Professional and Scientific papers contained in the United States Coast Survey Reports from* 1851 *to* 1870. Constituting Appendix 17 in the Report for 1871.—The Coast Survey Reports issued under the late eminent Superintendent, Prof. Bache, and also his able successor, Prof. Peirce, contain a large number of original memoirs of high scientific character,

and consequently this Index has great importance. The volumes contain many papers discussing tides in general, and the tides of the Atlantic, Pacific, and of special portions of the coast of the United States by Professor Bache; also others on tides, by C. A. Schott, G. Wurdemann, &c.; several papers on the Gulf Stream, its depth, temperature and soundings, by Prof. Bache, with others by E. B. Hunt, H. Mitchell, &c.; papers on hydrographic changes produced by tides and currents; on the measurements of heights, by T. J. Cram; on the chronometric determinations of longitude, by W. C. and G. P. Bond, A. D. Bache, C. A. Schott; on telegraphic determinations of longitude, by S. C. Walker, B. A. Gould, G. W. Dean, &c.; on longitude by occultations of the Pleiades, and lunar tables used in the same, etc., by Prof. Peirce; on the observations of the solar eclipse of July, 1851, with reference to longitude determinations, by Prof. Peirce; use of zenith-telescope for observations of time, by J. E. Hilgard; on star-catalogues, by C. A. Schott; on solar eclipses, by various authors; on solar spots, by C. A. Schott; on the moon's mass, as deduced from a discussion of the tides of Boston harbor, by William Ferrel; on deep sea soundings, by W. P. Trowbridge; on terrestrial magnetism, giving observations in the United States and general discussions, by Prof. Bache (and including his memoir on his magnetic survey of Pennsylvania and the adjoining States in 1834 to 1862), Mr. Schott (whose papers are very numerous), W. P. Trowbridge, J. E. Hilgard, G. W. Dean; on deep sea dredgings, by J. W. Bailey, L. F. Pourtalés, Prof. Agassiz; on the Florida coral reef, by Prof. Agassiz, also by E. B. Hunt; on earthquake waves in the Pacific, by A. D. Bache, also by J. E. Hilgard; besides a large number of papers bearing on other topics arising out of the survey. The papers on physical subjects are among the most important that have been anywhere published.

4. *On a Discovery of Meteoric Iron in Missouri;* by G. C. Broadhead (Mines, Metals and Arts, St. Louis, for Sept. 20).—Nearly six months ago I obtained knowledge of a mass of meteoric iron in Bates County, but only recently found out just where it was, and last week I went to Butler and obtained it. It was plowed up in a field by a man named Abram Crabbe, living eight miles southwest of Butler. For a long time it remained scarcely noticed by him, but at last, thinking it rather heavy, he brought it into Butler and left it at a blacksmith's. When I heard of its being there, I requested a fragment. A piece was cut off; the smith, first heating it, was occupied nearly two hours in the cutting.

This is the first meteorite that we know of having been found in Missouri. Its total weight is a little less than 90 pounds, and it is a rough-looking, rather irregular mass, somewhat pitted over the surface, as they generally are. From its great weight in comparison with its size and luster, I suppose it to be nearly all native iron with undoubtedly some nickel in its composition.

Pleasant Hill, Mo., September 1.

5. *On Poisons in relation to Medical Jurisprudence and Medicine.* By ALFRED SWAINE TAYLOR, M.D., F.R.S., &c. Third American, from the third English edition. Philadelphia, H. C. Lea. 1875. 8vo, pp. 788, with 104 illustrations in the text.—Dr. TAYLOR's manual on poisons long ago became a standard authority, and the appearance of a new and thoroughly revised edition brought down to May, 1875, will be welcomed by all interested in such studies. A rapid survey of the volume shows extensive changes, both by addition and omission. In fact the work has been remodelled in accordance with the changes of toxicological science, to meet the wants of students in law and medicine. B. S.

6. *On the Strength of the Lion and the Tiger*; by Rev. SAMUEL HAUGHTON.—In Nature, vol. xii, p. 474, in a review of Dr. Fayer's book on the tiger, doubts are thrown by the reviewer on the statement that the tiger is stronger than the lion. Dr. Fayer's statement cannot be contradicted by any person well acquainted with both animals. In my book on "Animal Mechanics," published in 1873, I have proved, p. 392, that the strength of the lion in the fore limbs is only 69·9 per cent of that of the tiger, and that the strength of his hind limbs is only 65·9 per cent of that of the tiger.

I may add that five men can easily hold down a lion, while it requires nine men to control a tiger. Martial also states that the tigers always killed the lions in the amphitheatre. The lion is, in truth, a pretentious humbug, and owes his reputation to his imposing mane, and he will run away like a whipped cur, under circumstances in which the tiger will boldly attack and kill.—*Nature, Oct.* 7, *in a letter dated Trinity College, Dublin, Oct.* 1.

OBITUARY.

WILLIAM JORY HENWOOD, F.R.S., F.G.S., died on the 5th of August, in his 71st year. He was the author of papers on Mineralogy, and of elaborate memoirs on the metalliferous deposits of Cornwall and Devon, and various other topics connected with mines and mining.

SAMUEL D. TILLMAN, Ph.D., LL.D., died September 4th, at the age of 62 years. Prof. Tillman's contributions to chemical literature have been mainly in the departments of chemical philosophy and nomenclature.

Unsere Körperform und das Physiologische Problem ihrer Entstehung. Briefe an einen befreundeten Naturforscher von WILHELM HIS. Mit 104 Holzschnitten. Leipzig, Verlag von F. C. Vogel, 1875. 8vo, pp. 224.

Cholera Epidemics of 1873 in the United States. 1026 pp. 8vo. Washington, 1875. 43d Congress, 2d session, House of Representatives. Ex. Doc. No. 95. Besides the long detailed Report on the Cholera epidemic of 1873 in North America by John M. Woodworth, M.D., this volume contains a report by Ely McClellan, M.D., on that of 1832, 1833, 1834, of 1848, of 1854, and of 1865, 1866, in North America; and also a history of the travels of Asiatic Cholera in Asia and Europe, by John C. Peters, M.D. The volume is illustrated by maps, and closes with a very extended bibliography.

APPENDIX.

ART. LI.—*On the Odontornithes, or Birds with Teeth;* by Prof. O. C. MARSH. With plates IX and X.

REMAINS of birds are among the rarest of fossils, and few have been described except from the more recent formations. With the exception of *Archæopteryx* from the Jurassic, and a single species from the Cretaceous, no birds are known in the old world below the Tertiary. In this country, numerous remains of birds have been found in the Cretaceous, but there is no satisfactory evidence of their existence in any older formation, the three-toed footprints of the Triassic being probably all made by Dinosaurian reptiles.

The Museum of Yale College contains a large series of remains of birds from the Cretaceous deposits of the Atlantic coast and the Rocky Mountain region, thirteen species of which have already been described by the writer. The most important of these remains, so far as now known, are the *Odontornithes*, or birds with teeth, and it is the object of the present communication to give some of the more marked characters of this group, reserving the full description for a memoir now in course of preparation.

The first species of birds in which teeth were detected was *Ichthyornis dispar* Marsh, described in 1872.* Fortunately the type specimen of this remarkable species was in excellent preservation, and the more important portions of both the skull and skeleton were secured. These remains indicate an aquatic bird, fully adult, and about as large as a pigeon.

The skull is of moderate size, and the eyes were placed well forward. The lower jaws are long, rather slender, and the rami were not coössified at the symphysis. In each lower jaw there are twenty-one distinct sockets, and the series extends over the entire upper margin of the dentary bone, (Plate IX, figures 1 and 2). The teeth in these sockets are small, compressed and pointed, and all are directed more or less backward. The crowns are covered with nearly smooth enamel. The maxillary teeth appear to have been numerous, and essentially the same as those in the mandible. Whether the premaxillary bones supported teeth, or were covered with a horny beak cannot be determined from the present specimen.

* This Journal, vol. iv, p. 344, and vol. v, p. 74.

The scapular arch and the bones of the wings and legs all conform closely to the true avian type. The sternum has a prominent keel, and elongated grooves for the expanded coracoids. The wings were very large in proportion to the legs, and the humerus had an extended radial crest. The metacarpals are coössified, as in recent birds, thus differing widely from those of *Archæopteryx*. The bones of the posterior extremities are slender, and resemble those of some aquatic birds. The centra of the vertebræ are all biconcave, the concavities at each end being distinct, and nearly equal. (Plate IX, figures 3 and 4.) The sacrum is elongated, and made up of a large number of coössified vertebræ. Whether the tail was elongated or not cannot at present be decided.

The jaws and teeth of this species show it to have been carnivorous, and it was probably aquatic. Its powerful wings indicate that it was capable of prolonged flight.

Another Cretaceous bird, (*Apatornis celer* Marsh,) belonging apparently to the same order as *Ichthyornis*, was found by the writer in 1872 in the same geological horizon in Kansas.* The remains preserved indicate an individual about the same size as *Ichthyornis dispar*, but of more slender proportions. The vertebræ are biconcave, and there were probably teeth.

The most interesting bird with teeth yet discovered is perhaps *Hesperornis regalis*, a gigantic diver, also from the Cretaceous of Kansas, and discovered by the writer in 1870. The type specimen, which was found by the writer in 1871, and described soon after, consisted mainly of vertebræ and the nearly complete posterior limbs, all in excellent preservation.†

A nearly perfect skeleton of this species was obtained in Western Kansas by Mr. T. H. Russell and the writer in November, 1872, during the explorations of the Yale College party, and several other less perfect specimens have since been secured, and are now in the Yale Museum. These various remains apparently all belong to one species.

The skull of *Hesperornis* has the same general form as that in *Colymbus torquatus* Brün., but there is a more prominent median crest between the orbits, and the beak is less pointed. The brain cavity was quite small. The maxillary bones are masive, and have throughout their length a deep inferior groove which was thickly set with sharp, pointed teeth. These teeth had no true sockets, but between their bases there are slight projections from the sides of the grooves. (Plate X, figure 2.) The teeth have pointed crowns, covered with enamel, and supported on stout fangs. (Plate X, figure 1*a*.) In form of crown and base, they most resemble the teeth of Mosasauroid reptiles. The method of replacement, also, was

* This Journal, v, 74, Jan., 1873. † This Journal, iii. 360, May, 1872.

the same, as some of the teeth preserved have the crowns of the successional teeth implanted in cavities in their fangs. The maxillary grooves do not extend into the premaxillaries, and the latter do not appear to have supported teeth. The external appearance, moreover, of the premaxillaries seems to indicate that these bones were covered with a horny bill, as in modern birds.

The lower jaws are long, and slender, and the rami were united in front only by cartilage. The dentary bone has a deep groove throughout its entire length, and in this, teeth were thickly planted, as in the jaws of *Ichthyosaurus*. The lower teeth are similar to those above, and all were more or less recurved. (Plate X, figure 1.) These grooves contain slight projections from the sides, but there are no true sockets. (Plate X, figure 2.)

The scapular arch of *Hesperornis* presents many features of interest. The sternum is thin and weak, and *entirely without a keel*. In front, it resembles the the sternum of *Apteryx*, but there are two very deep posterior emarginations, as in the Penguins. The scapula and coracoid are very small. The wing bones are diminutive, and the wings were rudimentary, and useless as organs of either flight or swimming.

The vertebræ in the cervical and dorsal regions are of the true ornithic type, the articular faces of the centra being quite as in modern birds. (Plate X, figures 3 and 4.) The sacrum is elongated, and resembles that in recent diving birds The last sacral vertebra is quite small. The caudal vertebræ, which are about twelve in number, are very peculiar, and indicate a structure not before seen in birds. The anterior caudals are short, with high neural spines and moderate tranverse processes. The middle and posterior caudals have very long and horizontally expanded tranverse processes, which restrict lateral motion, but clearly indicate that the tail was moved vertically, probably in diving. The last three or four caudal vertebræ are firmly coössified, forming a flat terminal mass, analogous to, but quite unlike, the "ploughshare" bone of modern birds. The anterior two at least of these caudals have expanded transverse processes.

The pelvic bones, although avian in type, are peculiar, and present some well marked reptilian features. A resemblance to the corresponding bones of the Cassowary is at once evident, especially in a side view, as the ilium, ischium, and pubis all have their posterior extremities separate. The two latter are slender, and also free back of their union with the ilium at the acetabulum. The ischium is spatulate at its distal end, and the pubis rodlike. The acetabulum differs from that in all known birds, in being closed internally by bone, except a foramen, that perforates the inner wall.

The femur is unusually short and stout, much flattened anteroposteriorly, and the shaft curved forward. It somewhat resembles in form the femur of *Colymbus torquatus* Brün., but the great trochanter is proportionally much less developed in a fore-and-aft direction, and the shaft is much more flattened. The tibia is straight and elongated. Its proximal end has a moderately developed cnemial process, with an obtuse apex. The epi-cnemial ridge is prominent, and continued distally about one-half the length of the shaft. The distal end of the tibia has on its anterior face no ossified supratendinal bridge, differing in this respect from nearly all known aquatic birds. The fibula is well developed, and resembles that of the Divers. The patella is large, as in *Podiceps*, and in position extends far above the elevated rotular process of the tibia.

The tarso-metatarsal bone is much compressed transversely, and resembles in its main features that of *Colymbus*. On its anterior face there is a deep groove between the third and fourth metatarsal elements, bounded on its outer margin by a prominent rounded ridge, which expands distally into the free articular end of the fourth metatarsal. This extremity projects far beyond the other two, and is double the size of either, thus showing a marked difference from any known recent or fossil bird. There is a shallow groove, also, between the second and third metatarsals. The second metatarsal is much shorter than the third or fourth, and its trochlear end resembles in shape and size that of the former. The existence of a hallux is indicated by an elongated oval indentation on the inner margin above the articular face of the second metatarsal. The free extremities of the metatarsals have the same oblique arrangement as in the *Colymbidæ*, to facilitate the forward stroke of the foot through the water. There are no canals or even grooves for tendons on the posterior face of the proximal end, as in the Divers and most other birds; but below this, there is broad, shallow depression, extending rather more than half way to the distal extremity.

The phalanges are shorter than in most swimming birds. Those of the large, external toe are very peculiar, although an approach to the same structure is seen in the genus *Podiceps*. On the outer, inferior margin, they are all deeply excavated. The first, second, and third have, at their distal ends, a single, oblique, articular face on the inner half of the extremity, and the outer portion is produced into an elongated, obtuse process, which fits into a corresponding cavity in the adjoining phalanx. This peculiar articulation prevents flexion except in one direction, and greatly increases the strength of the joints. The terminal phalanx of this toe was much compressed. The third, or middle, toe was greatly inferior to the fourth in size, and had

slender, compressed phalanges, which correspond essentially in their main features with those of modern Divers.

The remains preserved of *Hesperornis regalis* show that this species was larger than any known aquatic bird. All the specimens discovered are in the Yale College Museum, and agree essentially in size, the length from the apex of the bill to the end of the toes being between five and six feet. The habits of this gigantic bird are clearly indicated in the skeleton, almost every part of which has now been found. The rudimentary wings prove that flight was impossible, while the powerful swimming legs and feet were peculiarly adapted to rapid motion through the water. The tail appears to have been much expanded horizontally, as in the Beaver, and doubtless was an efficient aid in diving, perhaps compensating in part for want of wings, which the Penguins use with so much effect in swimming under water. That *Hesperornis* was carnivorous is clearly proven by its teeth; and its food was probably fishes.

The zoological position of *Hesperornis* is evidently in the *Odontornithes;* but the insertion of the teeth in grooves, the absence of a keel on the sternum, and the wide difference in the vertebræ require that it be placed in a distinct order, which may be called *Odontolcæ*, in allusion to the position of the teeth in grooves.

The two orders of birds with teeth would then be distinguished as follows:—

Sub-Class, ODONTORNITHES (or AVES DENTATÆ).

A. Teeth in sockets. Vertebræ biconcave. Sternum with keel. Wings well developed.

Order, ICHTHYORNITHES.

B. Teeth in grooves. Vertebræ as in recent birds. Sternum without keel. Wings rudimentary.

Order, ODONTOLCÆ.

In comparing *Ichthyornis* and *Hesperornis*, it will be noticed that the combination of characters in each is very remarkable, and quite the reverse of what would naturally be expected. The former has teeth in distinct sockets, with biconcave vertebræ; while the latter has teeth in grooves, and yet vertebræ similar to those of modern birds. In point of size, and means of locomotion, the two present the most marked contrast. The fact that two birds, so entirely different, living together during the Cretaceous, should have been recovered in such perfect preservation, suggests what we may yet hope to learn of life in that period.

The geological horizon of all the *Odontornithes* now known is the Upper Cretaceous. The associated vertebrate fossils are mainly Mosasauroid reptiles and Pterodactyls.

A full description with plates of all the known *Odontornithes* is now being prepared by the writer.

Yale College, New Haven, Oct. 18th, 1875.

EXPLANATION OF PLATES.

Plate IX.—*Ichthyornis dispar* Marsh. Twice natural size.

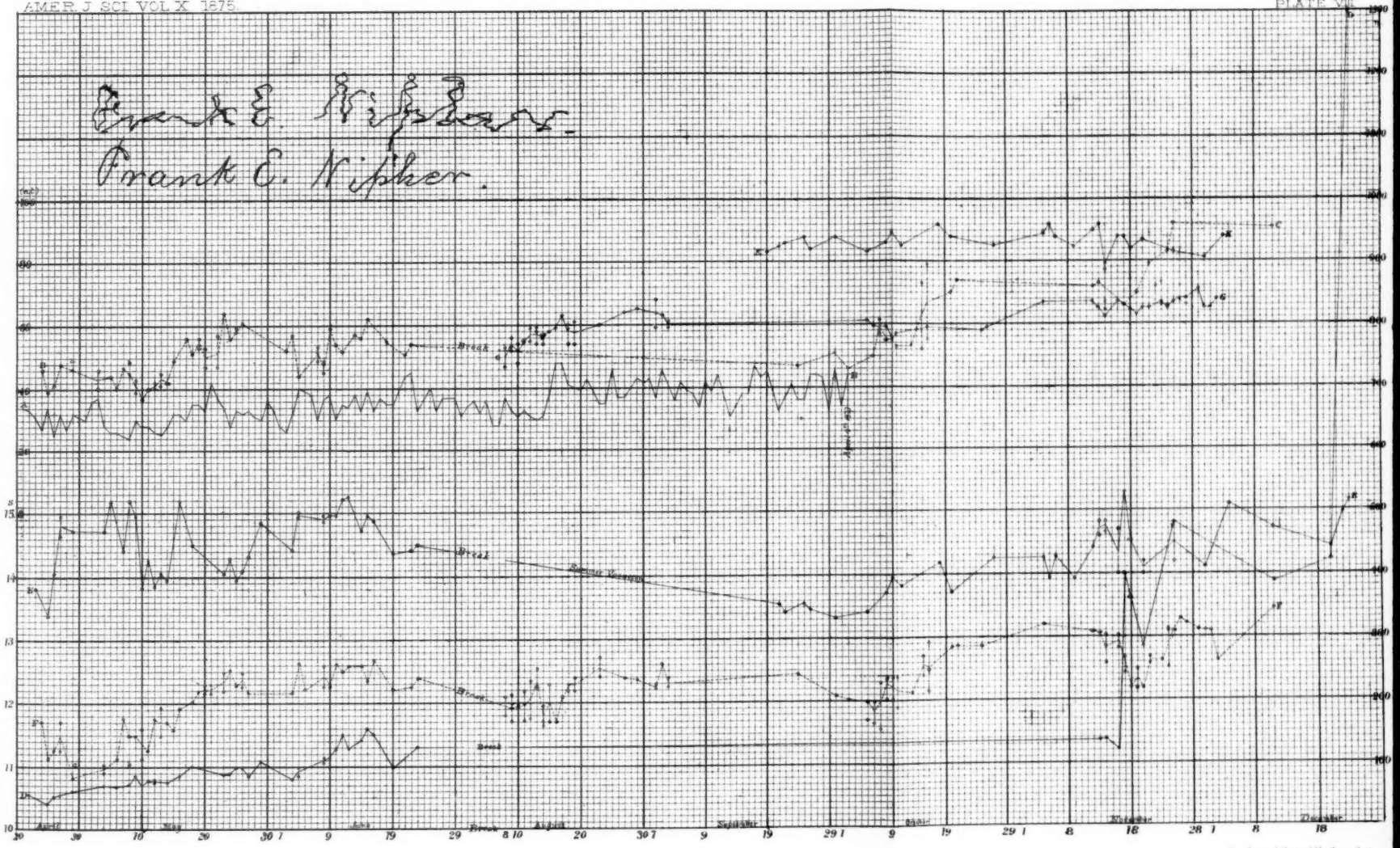
Figure 1. Left lower jaw; side view.
Figure 2. Left lower jaw; top view.
Figure 3. Cervical vertebra; side view.
Figure 4. Same vertebra; front view.

Plate X.—*Hesperornis regalis* Marsh.

Figure 1. Left lower jaw; side view; half natural size.
Figure 1*a*. Tooth; four times natural size.
Figure 2. Left lower jaw; top view; half natural size.
Figure 3. Dorsal vertebra; side view; natural size.
Figure 4. Same vertebra; front view.

ICHTHYORNIS DISPAR Marsh, $\frac{3}{4}$

HESPERORNIS REGALIS Marsh.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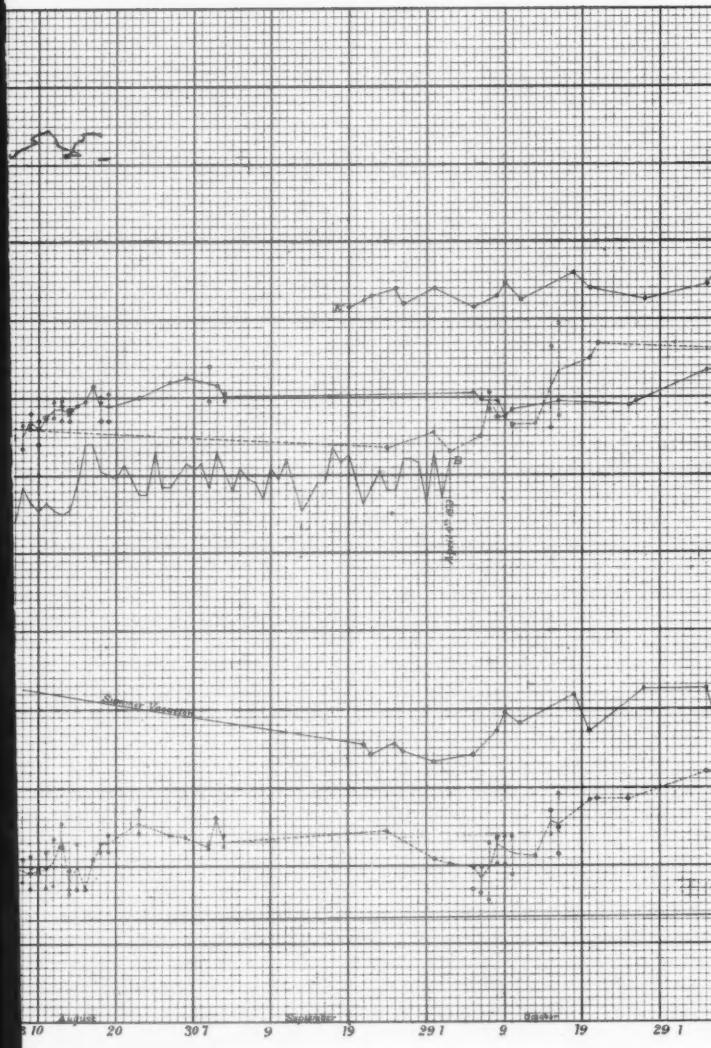
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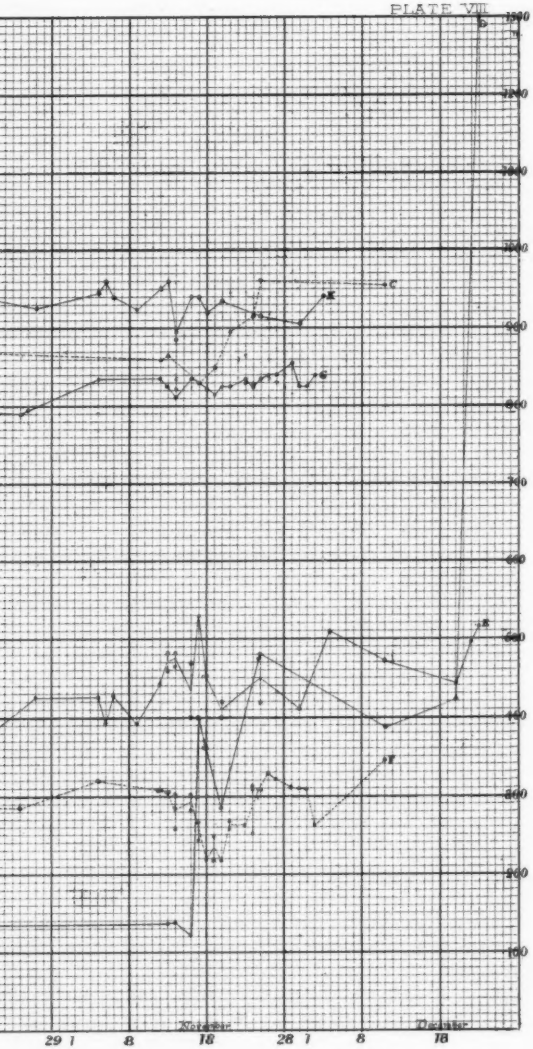
PLATE VIII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